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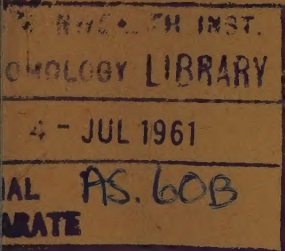
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The Soil and Water Abstracting and Indexing Project, Colorado State University Research Foundation, Fort Collins, Colorado, U.S.A., has undertaken a world-wide comprehensive Abstracting and indexing Service in the field of Soil and Water.

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# ECONOMIC ANALYSIS OF FERTILIZER TRIAL DATA ON PADDY AND WHEAT

T. P. ABRAHAM and V. Y. RAO

*Indian Council of Agricultural Research, New Delhi*

Received: June 15, 1959

With the rapid increase in the use of chemical fertilizers in crop production in the country, there has been considerable expansion in research on fertilizer use in relation to crop response. A large number of fertilizer trials are being carried out in experimental farms and in cultivators' fields. An economic analysis of the data, thus collected needs to be carried out for determining optimum fertilizer levels and combinations to be recommended to the cultivators for different crops and regions, under different price levels of the produce and fertilizer materials. In the past, whatever limited studies have been carried out in this country on this aspect, generally related to the determination of optimum levels for each nutrient separately. It is obvious that this approach of considering each fertilizer separately is satisfactory only if there are no interactions among the various nutrients. When two or more fertilizers are found to interact on crop response, the optimum amount of any of the fertilizers will depend on levels of other fertilizers applied. Optimum fertilizer combinations have to be worked out in such cases from response surfaces relating the yields with simultaneous variations in the levels of the various fertilizers. The results obtained in such a study on the data obtained in a series of fertilizer experiments with graded doses of nitrogen and phosphorus conducted in cultivators' fields are presented in this paper.

## MATERIAL AND METHODS

The data obtained from a series of co-ordinated simple fertilizer trials in cultivators' fields, carried out in different centres during 1953-54 to 1955-56 on paddy and wheat under a joint Indo-U.S. Scheme, form the basis of the present study (1959). In these experiments, which were also designed to compare different sources of nitrogen and phosphorus, two non-zero levels, each of 20 and 40 lb. of nitrogen and  $P_2O_5$ /per acre, were included, but due to practical limitations on the number of plots that can be accommodated in a field, all the factorial combinations of the two fertilizers at the specified doses could not be tried in the same trial.

The treatments in the three sets of trials, data of which could be utilized in the present study, were

- (1)  $o, n_1, n_2, n_1', n_2'$ ;
- (2)  $o, p_1, n_1p_1, n_2p_1, n_1'p_1, n_2'p_1$ ;
- (3)  $o, n_1, n_1p_1, n_1p_2, n_1p_1', n_2p_2'$ ;

where suffixes denote the levels 20 and 40 lb./acre, and dashes denote kinds of fertilizers. Only the data from nitrogen in the form of ammonium sulphate (n) and phosphorus (p) in the form of super (p) and their combinations have been utilized in this study, as

these are the standard fertilizers generally used in the country. It may be seen that out of the nine factorial combinations, with three levels of each of the two fertilizers, treatments  $p_2$  and  $n_2p_2$  have not been included in the trials. The experiments were carried out in 11 community project centres on paddy and in ten centres on irrigated wheat. At each centre, villages were first selected at random and two experimental fields were selected at random from each of the selected villages. One unreplicated experiment was laid out in each such selected field. In all about 2,672 experiments on paddy and 2,130 on wheat were carried out during the course of the three years. It is evident that the economic analysis of fertilizer use should have been made for different soil-climatic regions separately, but the data available were considered inadequate to give separate recommendations with a fair degree of accuracy. Therefore, the study has been confined only to the overall averages of all centres and years.

### *Method of Analysis*

Investigations on the suitability of different functional models for describing yield-dose relationship with data of fertilizer experiments in India, carried out by Rao (unpublished) indicated that a simple quadratic response function of the form  $Y = a + bx + cx^2 + dz + ez^2 + f3n$  (where  $Y$  represents the yield and  $x$  and  $z$  represent the two nutrients) is satisfactory in most cases. This form has, therefore, been adopted in the present study.

From the nature of the treatments in different trials, it is clear that some treatment comparisons such as  $n_1p_1$  and  $n_2$  are confounded with field differences. Further, the number of experiments has not been the same for all treatments. Due to these reasons, the accuracy of the estimates of different effects is not the same. Adjustments for confounding can be made by the well known method of fitting of 'constants', but in the present case corrections for block differences based on the control plots which occur in all the sets have been found to lead to practically the same estimates as the least square estimates. Therefore, the data were corrected in this manner. In fitting response surfaces, it is possible to take into consideration the unequal precision of the adjusted yields of different treatment combinations by using the inverses of the variance as weights in fitting, but as these weights did not differ appreciably, no such weightage was given in fitting. The adjusted averages over all the centres are given below, while the averages for individual centres are given in Appendix I.

TABLE I. MEAN YIELD (MD./ACRE) OF ALL CENTRES OVER THREE YEARS

Crop	n lb./acre p lb./acre	0	20	40	0	20	40	20
		0	0	0	20	20	20	40
Paddy		21.4	25.9	28.0	25.0	28.0	29.3	29.2
Wheat		15.1	18.1	19.8	17.4	19.4	21.0	20.4

From the overall means, it is evident that the response to a combined dose of nitrogen and phosphorus is significantly lower than expected, if the responses to the two

fertilizers were additive. Due to the presence of this interaction, it is necessary to base the economic analysis on a two variable response surface rather than on univariate response curves.

### Fitted Response Surfaces

The method of fitting a quadratic response surface is given in detail in Appendix II. The values of constants of the fitted surface together with the standard errors of these constants are given below, the equation to the surface being

$$Y = a + bn + cn^2 + dp + ep^2 + fnp \quad (1)$$

where Y is the yield in md./acre; n: lb. /N/acre applied and p. : lb phosphorus per acre applied.

VALUES OF CONSTANTS OF FITTED QUADRATIC RESPONSE SURFACES

Constant	Crop: Paddy		Crop: Wheat	
	Fitted value	S.E. of fitted constants	Fitted value	S.E. of fitted constants
a	21.4583		15.2099	
b	0.2675	0.06052	0.1578	0.02790
c	-0.00256	0.001171	-0.00104	0.0005696
d	0.2054	0.05688	0.12076	0.02764
e	-0.00156	0.001171	-0.00086	0.0005696
f	-0.00288	0.001353	0.00125	0.0006577

The equation to the surfaces are therefore:

$$Y_p = 21.4583 + 0.2675n - 0.00256n^2 + 0.2054p - 0.00156p^2 - 0.00288np \quad (2)$$

$$Y_w = 15.2099 + 0.1578n - 0.00104n^2 + 0.1208p - 0.00086p^2 - 0.00125np \quad (3)$$

$Y_p$  and  $Y_w$  being the yields for paddy and wheat respectively.

The adequacy of the fit is tested by the analysis of variance of the regression surface as shown below. The error variance given is the interaction of treatments with centres.

TABLE II. ANALYSIS OF VARIANCE OF FITTED RESPONSE SURFACES

Source of variation	d. f.	Paddy M. S.	Wheat M. S.
Fitted surface	5	9.5937	5.0573
Residual	1	0.0408	0.0972
Error	60	0.2931	0.0692

For wheat d. f. = 54

It will be seen that in both cases the residual variation is small and statistically not significant. The error variance is lower for wheat indicating thereby more uniformity of responses from centre to centre in this crop. This is to be expected as the wheat tract consists of a relatively homogeneous area and all the experiments were carried out under irrigated conditions. The fitted surface can be utilised to estimate the yields for various combinations of the two fertilizers. Figs. 1(p) and 1(w) give the response surfaces for paddy and wheat respectively.

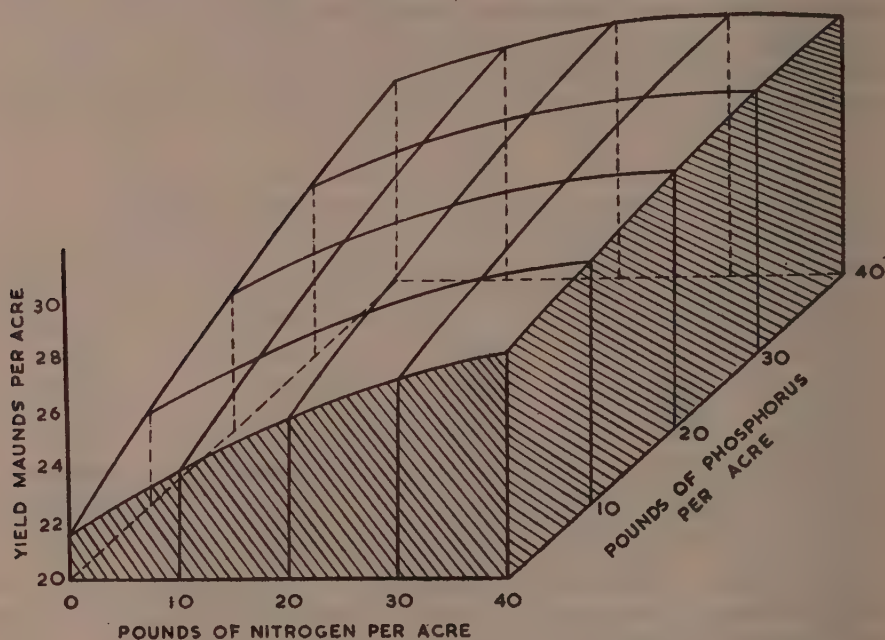


FIG. 1 (P): PREDICTED YIELD RESPONSE SURFACE FOR PADDY

The estimated yields to different fertilizer combinations are given in Table III.

As the highest doses tried are 40n and 40p, estimates of yields for higher levels are not given.

#### OBSERVATIONS

##### *Economic Analysis of the Fitted Surfaces*

(i) *Optimum doses*: If  $Y=f(n, p)$  is the response function, the levels of  $n$  and  $p$  maximising net profits will be given by that combination at which the value of the additional produce obtained by small increments of each fertilizer will just balance the cost of the added fertilizers. In other words, the marginal return must be equal to the marginal cost. Thus at the optimum

$$p_1 \Delta f = q_1 \Delta n \quad (3)$$

$$p_2 \Delta f = q_2 \Delta p$$

TABLE III. ESTIMATED YIELDS FOR VARIOUS LEVELS OF FERTILIZER COMBINATIONS (md./acre)

Crop	Level of p lb./acre	Level of n lb./acre							
		0	10	15	20	25	30	35	40
Paddy	0	21.5	23.9	24.9	25.8	26.5	27.2	27.7	28.1
	10	23.4	25.5	26.4	27.1	27.7	28.2	28.6	28.8
	15	24.2	26.2	27.0	27.7	28.2	28.6	28.9	29.1
	20	24.9	26.8	27.5	28.1	28.6	28.9	29.2	29.2
	25	25.6	27.3	28.0	28.5	28.9	29.2	29.3	29.3
	30	26.2	27.8	28.4	28.8	29.1	29.3	29.4	29.4
	35	26.7	28.1	28.7	29.0	29.3	29.4	29.4	29.3
	40	27.2	28.4	28.9	29.2	29.4	29.4	29.4	29.2
Wheat	0	15.2	16.7	17.3	18.0	18.5	19.0	19.5	19.9
	10	16.3	17.7	18.3	18.8	19.3	19.8	20.1	20.5
	15	16.8	18.1	18.7	19.2	19.7	20.1	20.4	20.7
	20	17.3	18.5	19.0	19.5	20.0	20.3	20.7	20.9
	25	17.7	18.9	19.4	19.8	20.2	20.4	20.8	21.1
	30	18.4	19.2	19.6	20.1	20.4	20.7	21.0	21.2
	35	18.4	19.4	19.9	20.2	20.6	20.9	21.1	21.3
	40	18.7	19.6	20.0	20.4	20.7	21.0	21.2	21.3

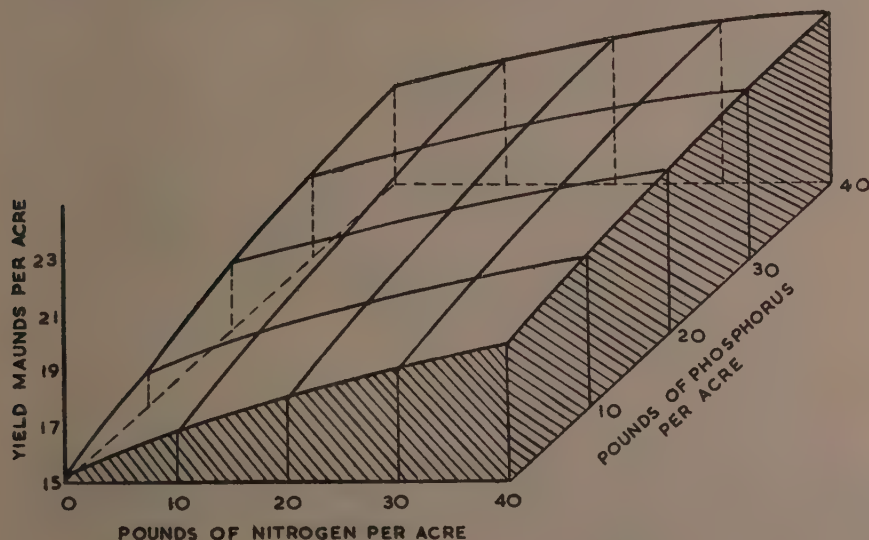


FIG. 1 (W): PREDICTED YIELD RESPONSE SURFACE FOR WHEAT

where  $p_1$  is the price per unit of produce,  $q_1$  and  $q_2$  are costs per unit of nitrogen and phosphorus respectively and  $\Delta f$  denotes the small increment in yield with small

increments  $\Delta n$  and  $\Delta p$  of the fertilizers. These lead to the equations

$$p_1 \frac{\delta f}{\delta n} = q_1 \quad (4)$$

$$p_1 \frac{\delta f}{\delta p} = q_2$$

where the symbols  $\frac{\delta}{\delta n}$ , etc., denote the partial derivatives. The solution of equations (4) gives the optimum.

The prices of one maund of paddy ( $p_1$ ) and one maund of wheat ( $p_2$ ) at the present rates may be taken as Rs. 12 and Rs. 16 respectively. The cost of one pound of nitrogen ( $q_1$ ) in the form of Ammonium Sulphate (20% N) at the current rate of Rs. 380 per ton is Re. 0.84821. Cost of one pound of phosphorus ( $q_2$ ) in the form single super (16%  $P_2O_5$ ) at the current rate of Rs. 265 per ton is Re. 0.73940. These rates include the cost of transport of fertilizer to the location. The cost of fertilizer application, other than the cost of fertilizers is assumed negligible.

The equations giving optimum doses of n and p are given below. These equations are derived from (2) using the equations (4)

$$-0.00512n - 0.00288p + 0.2675 = q_1/p_1 = 0.07068$$

$$-0.00288n - 0.00312p + 0.2054 = q_2/p_2 = 0.06162$$

Similar equations giving optimum doses of the fertilizers for wheat derived from the response surface (3) are

$$-0.00208n - 0.00125p + 0.1578 = q_1/p_2 = 0.05301$$

$$-0.00125n - 0.00172p + 0.1208 = q_2/p_2 = 0.04621$$

The optimum combination of n and p for paddy and wheat are given in Table IV.

TABLE IV. OPTIMUM COMBINATIONS OF NITROGEN AND PHOSPHORUS

Crop	Optimum dose (lb./acre)		Response to the optimum (md./acre)	Net profit (Re./acre)
	Nitrogen (n)	Phosphorus (p)		
Paddy	26	22	7.34	50
Wheat	43	12	5.54	43

It is interesting to note that the application of relatively more nitrogen and less phosphorus for wheat and almost the same quantities of nitrogen and phosphorus for paddy will bring in greater returns. The maximum net profits from manuring is not widely different for wheat and paddy but is in favour of paddy. It is obvious that the costs and prices are likely to vary. Alternative price expectations cause the optimum doses to vary. Optimum doses of fertilizers for various ratios of cost per unit of fertilizer to price per unit of produce can be read from Figs. 2(p) and 2(w) for paddy and wheat respectively. The smooth lines in these figures correspond each to a given

ratio of  $\frac{\text{cost of 1 lb. N}}{\text{price of 1 md. produce}}$  as indicated against the line, while the dotted lines correspond to similar ratios for phosphorus. The optimum doses of n and p for given ratios are obtained as the coordinates of the intersection of the corresponding

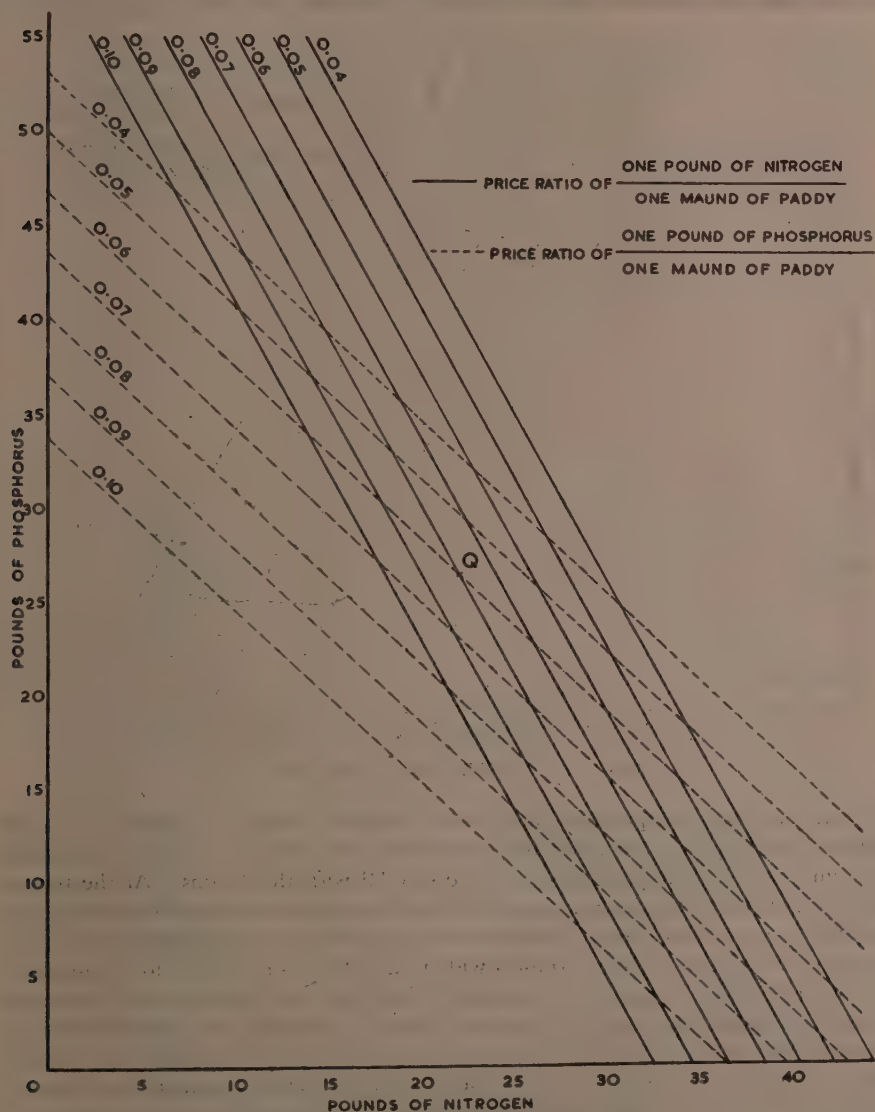


FIG. 2 (P): OPTIMUM VALUES FOR PADDY

smooth and dotted lines. Thus, if the cost price ratio for  $n$  is 0.08 and for  $p$  is 0.06, the optimum combination is  $n=22$  lb./acre,  $p=26$  lb./acre for paddy, these being the coordinates of the point  $Q$ , indicated in Fig. 2(p). It will be observed that some pairs of lines do not intersect in the +ve quadrant. In this case a zero dose of one or both of the fertilizers is indicated. For example, consider the optimum for wheat corresponding to a cost price ratio of 0.10 for  $p$  and 0.09 for  $n$ . Referring to Fig. 2(w)

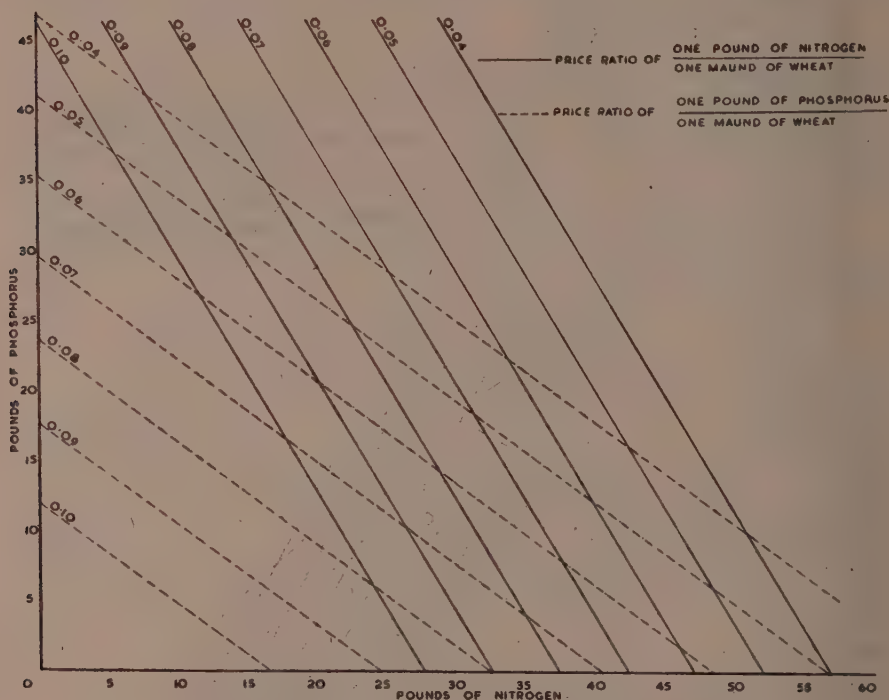


FIG. 2 (W): OPTIMUM VALUES FOR WHEAT

it is seen that the corresponding lines do not intersect in the +ve quadrant. The optimum will be  $p=0$  and  $n=32$  lb., these being the coordinates of the intersection of the smooth line corresponding to a ratio of 0.09 with the N axis. At the present rates, the cost price ratio for  $n$  is about 0.07 in the case of paddy and 0.05 for wheat. For ratios around these values, relatively larger application of phosphorus to paddy and nitrogen to wheat is indicated for a wide range of cost-price ratios for phosphorus.

It is interesting to note as is shown on facing page that at given price levels, considerable departure from the true optimum will not materially alter the net profits. The net profits are nearly the same for the various doses tried, in case of paddy and even in case of wheat the difference is not appreciable. The returns per unit investment is generally higher for paddy as compared to wheat and decrease in both cases with increased levels of fertilizer application.

TABLE 5. ECONOMICS OF ALTERNATIVE MANURIAL DRESSINGS

Rates of fertilizer Applications (lb./acre)		Response (md./acre)	Cost of ferti- zers (Re./acre)	Net profit (Re./acre)	Returns per unit investment
N	P				
Paddy Crop					
20	20	6.66	31.75	48.17	1.52
26	22	7.34	38.32	49.76	1.30
20	30	7.35	39.15	49.17	1.26
30	20	7.48	40.23	49.53	1.23
30	30	7.88	47.62	46.93	0.99
Wheat Crop					
20	20	4.31	31.75	37.21	1.17
30	30	5.11	40.23	41.53	1.03
20	30	4.84	39.15	38.29	0.98
43	12	5.54	45.35	43.29	0.95
20	40	5.19	46.54	36.50	0.78

(ii) *Optimum fertilizer combination for a given increase in production:* Sometimes, the interest may be to find out the optimum manurial dressings which will raise the production by a given amount. Generally, there will be a number of alternative combinations of nitrogen and phosphorous, application of which will achieve the desired target of additional production. If a plane parallel to the nutrient plane and at a distance  $Y_0$ , from this plane is drawn, the intersection of this plane with the response surface gives a curve, all points on which correspond to yield  $Y_0$ . The vertical projection of this curve on the nutrient plane gives the yield contour or isoquant corresponding to the yield level  $Y_0$ . The combinations of  $n$  and  $p$  corresponding to each point on the given isoquant gives rise to the same yield response. Of all these combinations at given levels, there will be one combination that will minimise the cost and thereby maximise the net profits at that yield level. This is the optimum combination for the particular yield level. From the response function, the optimum values of nitrogen and phosphorus can be obtained as follows:

Let  $Y_0$  be the yield corresponding to the desired additional production. Then

$$Y_0 = a + bn + cn^2 + dp + ep^2 + fnp \quad (5)$$

With  $q_1$  and  $q_2$  as unit costs of nitrogen and phosphorus respectively. The cost of fertilizer is  $C = q_1n + q_2p$ . The choice of  $n$  and  $p$  to minimise  $C$  subject to (5) leads to the equation

$$\frac{\partial f(np)}{\partial n} \bigg/ \frac{\partial f(np)}{\partial p} = \frac{q_1}{q_2} \quad (6)$$

Equation (6) and (5) give the optimum values of  $n$  and  $p$ . For the quadratic surface, equation (6) is seen to be

$$q_2(b+fp+2cn)=q_1(d+2ep+fn) \quad (7)$$

The solutions of this equation along with (5) give the optimum combinations. By varying  $Y_0$ , optimum combinations for various yield levels can be found. It will be noted that at the optimum  $\frac{\Delta n}{\Delta p} = \frac{q_2}{q_1}$  i.e. the replacement ratio of fertilizer is equal to

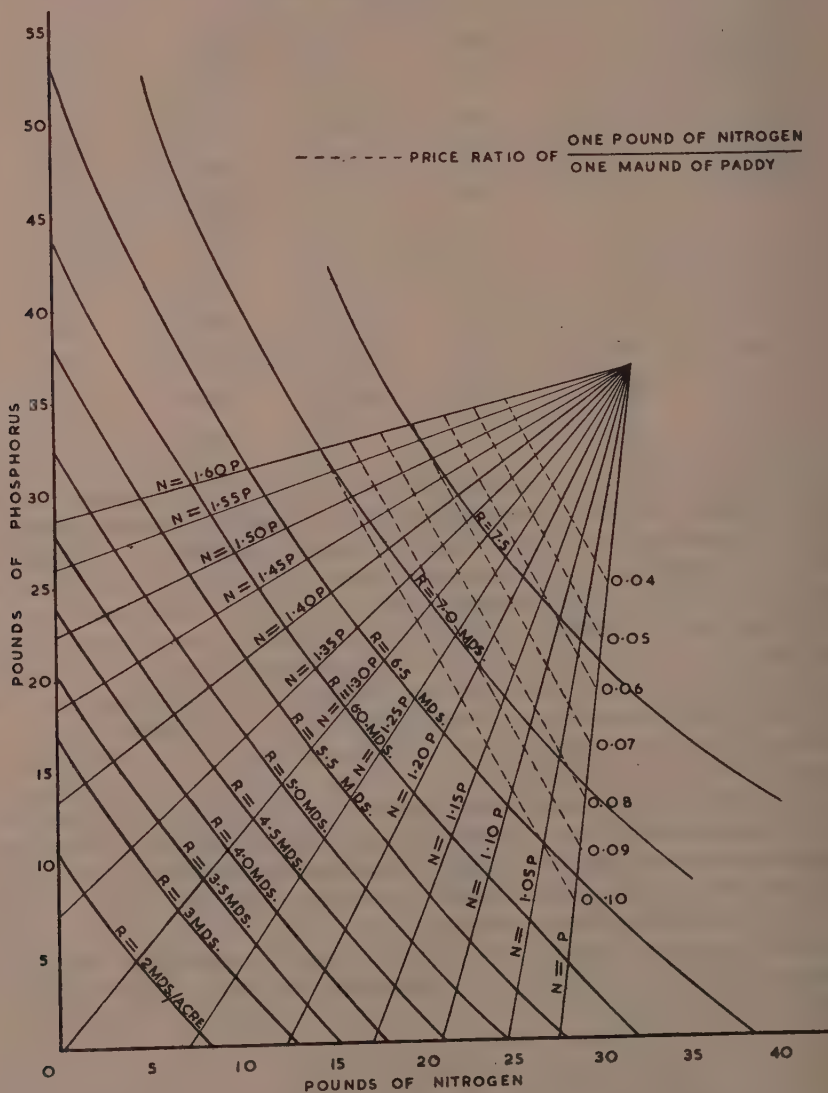


FIG. 3 (P): YIELD ISOQUANTS AND ISOCLINES FOR PADDY

inverse price ratio. Equation (7) represents a straight line and is independent of the particular yield level. This line gives the locus of points which give optimum combinations corresponding to various yield levels and is called an isocline. With a different ratio of  $q_1/q_2$  we get a different isocline. For paddy and wheat, the isoclines and isoquants are given in Figs. 3(p) and 3(w) using which the optimum combination for different yield levels and values of the ratio  $q_1/q_2$  can be found out. It will be seen that the slopes of the isoquants are relatively constant over the entire range of fertilizer levels. The average slope of the isoquants for paddy is about 1.3 to 1.4, while for wheat the slope ranges from about 1.4 to 1.6. Therefore, about 1.3 to 1.4 lb.  $P_2O_5$  should be added to replace a lb. of nitrogen in the manuring of paddy and the corresponding rate of substitution in the case of wheat is about 1.4 to 1.6  $P_2O_5$  per lb. of nitrogen replaced. The relative efficiency of phosphorus compared to nitrogen is more for paddy than for wheat. At the present price levels  $\frac{\text{cost of 1 lb. N}}{\text{cost of 1 lb. } P_2O_5} = 1.15$  it is evident from the substitution rate of nitrogen by phosphorus, the present price level of phosphorus is considerably higher in relation to that of nitrogen.

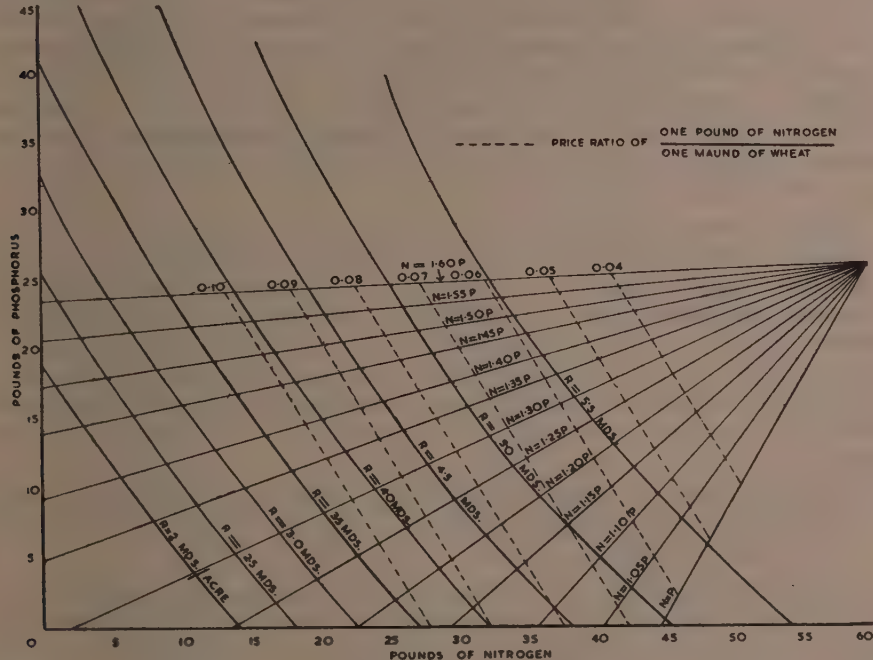


FIG. 3 (W): YIELD ISOQUANTS AND ISOCLINES FOR WHEAT

The coordinates of the inter-section of the isocline corresponding to a particular nitrogen-phosphorus price ratio with the isoquant corresponding to a given yield level, give the optimum (least cost combination) combination of the two fertilizers to obtain

the given response. Considering the intersection of isocline labelled  $N=1.15 P$  (which corresponds to the present price levels), with the isoquants, it is seen that a response of upto about 4.5 md./acre is best obtained mainly through application of nitrogen alone, but larger responses are more economically obtained mainly through further addition of progressively larger amounts of phosphorus particularly for paddy. Figures 3(p) and 3(w) can also be used to determine the optimum doses for given price levels of the produce and the fertilizers as illustrated below:

Net price of paddy	=Rs. 12.00/md.
Price of nitrogen	=Re. 0.85/lb.
Price of $P_2O_5$	=Re. 0.74/lb.
Price relationship of N to P is	$N = 1.15 P$
Price relationship of N to Paddy is	$\frac{0.85}{12.00} = 0.07$

The optimum combinations of N and P for all levels of production when nitrogen is 1.15 times as expensive as phosphorus is given by the points on the isocline  $N=1.15 P$ . To find out how far we should go along this line to maximise the net profit, it is necessary to find the nitrogen-paddy price ratio. In the present illustration this ratio is 0.07. Therefore, the line labelled  $N=1.15 P$  is followed until the dashed line 0.07 is reached. Reading the coordinates of the intersection of the isocline  $N=1.15 P$  with the dashed line 0.07, we find the optimum as 26 lb. N and 22 lb.  $P_2O_5$ . Determination of paddy yield for the indicated doses can be made from the isoquant. By interpolation it will be found that the yield isoquant passing through the intersection point corresponds to about 7.3 md./acre.

(iii) *Optimum use of N and P for a given outlay*: For a farmer with limited capital it will not be generally possible to invest on fertilizers the amount which will maximise his net profits from fertilizer use. He will have to consider not only the allocation to his limited funds between various input factors such as better seeds, cultivation practices, manuring, etc., but also the optimum allocation of the funds allotted to fertilizer use between different nutrients. It can be easily shown that with a fixed outlay  $c$  on fertilizers, the optimum allocation is given by the intersection of the isocline corresponding to the particular ratio  $q_1/q_2$  with the cost line  $C=q_1n+q_2p$  for the given value of  $C$ .

Figs. 3(p) and 3(w) can be made use of for determining the optimum combination with a given outlay as illustrated below:

Let the outlay=Rs. 25/acre.

The cost line at the present price rates of N and P (given on page No. 6) can be written as  $0.85 N + 0.74 P = 25$ . The intersection of this line with the N-axis is at  $\frac{25}{0.85} = 29.4$  lb. on N-axis. Similarly the intersection with P-axis is  $\frac{25}{0.75} = 33.4$  lb. along P-axis. By arranging a straight edge from 29.4 on N-axis and 33.8 lb. on P-axis, we locate the point of intersection of this straight edge with the isocline labelled  $N=1.15 P$ . The coordinates of this point of intersection give 21.0 lb. N and 9.5 lb.  $P_2O_5$  as the best use of the outlay of Rs. 25 on these two fertilizers.

(iv) *Allocation of a limited amount of fertilizer resources between wheat and paddy:* With a limited fertilizer supply, it is important to know how best to allocate the available resources between different competing crops. We may assume that the optimum allocation is one which maximises the net profits. It is, of course, recognised that there are circumstances which make such an allocation undesirable in the national interest, as it may lead to unequal development in different regions. Further, with the present food habits of the population, the higher production in one crop cannot be a complete substitute for the deficiency of another crop. In such cases all or most of the fertilizer supplies may be diverted to the production of that crop where shortage is most keenly felt. We shall not consider programming in such situations.

TABLE VI. OPTIMUM ALLOCATION OF VARIOUS AMOUNTS OF N AND P TO WHEAT AND PADDY

$$\frac{\text{Price of 1 md. of paddy}}{\text{Price of 1 md. of wheat}} = 0.75$$

Total quantity for two acres in lb.		Quantity to be distributed between paddy and wheat				Additional Production	
N	P	N		P		Wheat	Paddy
		Paddy	Wheat	Paddy	Wheat		
1	1(a)	2	3	4	5	6	7
20	20	10	10	13	7	4.4	2.2
40	20	18	22	10	10	5.5	3.7
60	20	27	33	8	12	6.3	4.9
80	20	35	45	6	14	6.8	5.7
20	30	8	12	19	11	4.9	2.8
40	30	17	23	16	14	5.9	4.2
60	30	25	35	14	16	6.6	5.3
80	30	34	46	11	19	7.1	6.0
20	40	7	13	24	16	5.3	3.4
40	40	15	25	22	18	6.3	4.6
60	40	24	36	19	21	6.9	5.6
80	40	32	48	17	23	7.4	6.1
20	60	3	17	35	25	5.8	4.3
40	60	12	28	33	27	6.8	5.3
60	60	20	40	30	30	7.4	6.0
80	60	29	51	28	32	7.8	6.2

Let  $Y_p$  and  $Y_w$  be the response functions for paddy and wheat. At the optimum, the marginal revenues with the use of each fertilizer should be the same for both crops. If  $p_1$  and  $p_2$  are the prices of paddy and wheat per md. respectively then by the above condition

$$p_1 \frac{\delta y_p}{\delta n_p} = p_2 \frac{\delta y_w}{\delta n_w}$$

$$p_1 \frac{\delta y_p}{\delta p_p} = p_2 \frac{\delta y_w}{\delta p_w}$$

where  $\frac{\delta y}{\delta n}$ , etc., denote partial derivatives and  $n_p$  and  $n_w$  are the nitrogen applied to paddy and wheat and  $p_p$ ,  $p_w$  are the quantities of phosphorus applied to the two crops.

The solutions of these two equations along with equations

$$n_p + n_w = q_n$$

$$p_p + p_w = q_p$$

where  $q_n$  and  $q_p$  are the given total amounts of nitrogen and phosphorus, give the optimum amounts of nitrogen and phosphorus to be distributed over an acre of paddy and wheat each. The price of 1 md. of paddy is taken as Rs. 12 and of wheat Rs. 16. The optimum allocation is independent of the cost of n and p and depends only on the relative prices of the two crops and the response functions. In all cases more nitrogen is indicated for wheat than for paddy. With a given amount of phosphorus, it is desirable to use more on paddy than on wheat when quantity of nitrogen is low, but with increase in the quantity of nitrogen available, the quantity of phosphorus has to be increased for wheat and reduced for paddy.

## SUMMARY

Fertilizer response surfaces were fitted to the data obtained in a series of simple fertilizer trials carried out on paddy and wheat crops for a period of three years in randomly selected cultivators' fields in selected community project centres. The fitted surface was analysed to determine the following.

- (1) The optimum doses of nitrogen and phosphorus.
- (2) Optimum fertilizer combinations for fixed targets of production or a fixed outlay.

(3) Optimum allocation of a limited fertilizer material for wheat and paddy. The main conclusions obtained are:

- (i) At the present ratio of fertilizer costs and prices of wheat and paddy, the optimum combinations to 26 lb.  $N+22$  lb.  $P_2O_5$  for paddy and 43 lb.  $N+12$  lb.  $P_2O_5$  for wheat. At these levels of application the net profit per acre is Rs. 50 and Rs. 43 for paddy and wheat respectively. Charts have been given from which optimal dressings can be found for alternative prices and costs.
- (ii) From the yield isoquants, the substitution rate of nitrogen by phosphorus has been worked out. About 1.3 to 1.4 lb.  $P_2O_5$  in the case of paddy and

1.4 to 1.6 lb.  $P_2O_5$  in the case of wheat are required to replace one lb. of nitrogen.

- (iii) A response of upto about 4.5 md./acre can be best achieved through application of nitrogen alone, but larger responses are more economically obtained through further additions of phosphorus.
- (iv) With a given outlay on fertilizers the optimum distribution of fertilizer to paddy and wheat has been worked out. It is best to apply relatively more nitrogen on wheat and more phosphorus on paddy.

#### ACKNOWLEDGEMENTS

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## APPENDIX I

MEAN YIELD (MD./ACRE) OF SIMPLE FERTILIZER TRIALS IN CULTIVATOR'S FIELDS-AVERAGE OF 3 YEARS 1953-54 TO 1955-56

Soil type	Centre	N lb./acre		P lb./acre		0		20		40		0		20		40		20		40		Average		No. of exps.
																				S.E.				
Crop: Paddy																								
(a) Alluvial (undifferentiated)	1. Agartala (Tripura)	21.8	26.7	28.7	25.5	27.8	29.2	28.6	0.54	59														
(b) Coastal alluvium	2. Darrang (Assam)	24.3	31.2	29.3	34.3	36.6	30.6	34.7	0.55	31														
(c) Red loam	3. Mangalore (Madras)	24.6	25.5	27.7	26.3	27.4	28.9	29.2	0.12	33														
(d) Laterite	4. Samalkota (Andhra)	29.9	32.8	35.2	32.4	36.2	37.3	37.3	0.36	29														
(e) Red and Yellow	5. Raneshwar (Bihar)	16.6	20.4	23.7	19.9	22.4	24.0	24.0	0.21	60														
(f) Medium black soil of trap and gneissic origin	6. Kalahandi (Orissa)	21.9	27.5	34.2	25.0	29.5	29.8	32.6	0.74	64														
(g) Grey and brown soils of Indo-Gangetic basin impugned with salts	7. Chalakudy (T.C.)	17.1	20.3	22.2	19.4	22.0	24.5	24.4	0.27	56														
	8. Raipur (M.P.)	16.3	21.5	25.3	19.8	23.2	26.8	24.4	0.29	61														
	9. Bodhan (Hyderabad)	22.6	24.6	23.9	25.3	27.1	28.9	29.6	0.31	64														
	10. Nilokheri (Punjab)	26.0	34.5	38.2	29.4	36.0	40.0	33.6	0.74	66														
	11. Pusa (Bihar)	14.2	19.4	19.8	17.2	20.2	21.7	24.8	0.34	54														
Average		21.4	25.9	28.0	25.0	28.0	29.3	29.2																
Crop: Wheat																								
(a) Grey and brown soils of Indo-Gangetic basin	1. Nawanshahar (Pb.)	16.6	20.7	23.4	19.8	22.6	23.0	24.4	0.20	69														
(b) Alluvial soils (undifferentiated)	2. Nilokheri (Pb.)	15.3	19.5	20.9	17.7	19.9	20.2	21.2	0.11	26														
	3. Bhadsan (Pepsu)	16.4	19.9	21.2	17.4	21.1	23.1	22.7	0.29	49														
	4. Alipur (Delhi)	16.4	19.2	22.6	17.9	20.6	23.1	22.4	0.25	39														
	5. Mehsana (Bombay)	19.9	23.0	23.5	22.6	23.8	24.5	25.2	0.25	52														
(c) Red and Yellow	6. Pilsanga (Ajmer)	10.0	12.6	14.0	11.4	13.1	15.0	13.0	0.30	31														
(d) Medium black soil of trap and gneissic origin	7. Manavadar (Saurashtra)	15.9	17.9	19.7	18.5	20.9	23.4	21.3	0.48	39														
(e) Sub-montane (Undifferentiated)	8. Kunihar (H.P.)	11.3	14.3	15.0	13.5	13.8	15.2	14.5	0.27	13														
	9. Raisinagar (Rajasthan)	20.5	23.0	25.7	24.0	26.0	27.5	26.7	0.39	43														
	10. Sammerpur (Rajasthan)	9.0	11.0	11.8	10.7	11.7	13.0	12.6	0.29	29														
Average		15.1	18.1	19.8	17.4	19.4	21.0	20.4																

## APPENDIX II

The procedure of fitting quadratic response surface  $y = a + bn + cn^2 + dp + ep^2 + fnp$ , where  $n$  and  $p$  are the levels of nitrogen and phosphorus and  $y$  is the yield.

The well known technique of fitting a multiple regression equation is used in fitting the surface

Ref. R. A. Fisher: *Statistical Methods for Research Workers*.

Let  $n = x_1$ ,  $n^2 = x_2$ ;  $p = x_3$ ;  $p^2 = x_4$  and  $np = x_5$

Then the regression function can be written as (after taking deviations from the respective means)

$$y = Bx_1 + Cx_2 + Dx_3 + Ex_4 + Fx_5$$

Taking the levels of nitrogen and phosphorus as -1, 0, 1 the values of the independent variates  $x_1, x_2, \dots$  etc. in the regression eqn are given below:

Yield	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$
$y_{-1-1}$	-1	1	-1	1	1
$y_{-10}$	-1	1	0	0	0
$y_{0-1}$	0	0	-1	1	0
$y_{00}$	0	0	0	0	0
$y_{01}$	0	0	1	1	0
$y_{1-1}$	1	1	-1	1	-1
$y_{10}$	1	1	0	0	0

where  $y_{ij}$  is the yield corresponding to levels  $i$  and  $j$  of  $n$  and  $p$  respectively.

The corrected sums of squares and sums of products between  $y$  and  $x_1, x_2, x_3, x_4, x_5$  are given in the following table for both paddy and wheat. The yields  $y_{ij}$  for paddy and wheat are taken from Table I as the averages of all the centres.

	$x_1$	$x_2$	$x_3$	$x_4$	$x_5$	y paddy	y wheat
$x_1$	4.0000	0.0000	0.0000	0.0000	-2.0000	10.9000	8.3000
$x_2$		1.7143	-0.8571	-0.2857	0.0000	-3.0429	-1.6629
$x_3$			3.4286	-0.8571	0.0000	7.2714	4.8514
$x_4$				1.7143	0.0000	-2.2429	-1.5229
$x_5$					2.0000	-6.6000	-4.6500
$y$						48.0086	25.3839

From the above table, the normal equations can be easily written down. From these equations, the C matrix (Variance Covariance Matrix) is obtained as

$C_{ij}$	$j=1$				
$i =$	0.50000	0.00000	0.00000	0.00000	0.50000
	0.00000	0.74996	0.24996	0.24996	0.00000
	0.00000	0.24996	0.41663	0.24996	0.00000
	0.00000	0.24996	0.24996	0.74996	0.00000
	0.50000	0.00000	0.00000	0.00000	1.00000

The constants are estimated as

$$= C_{i1} \sum x_1 y + C_{i2} \sum x_2 y + C_{i3} \sum x_3 y + C_{i4} \sum x_4 y + C_{i5} \sum x_5 y$$

when  $i=2, 3, 4, 5$  we get the values for the estimates of B, C, D, E and F

For paddy,

We find

$$\begin{aligned} B &= 2.15000 \\ C &= -1.02513 \\ D &= 1.70824 \\ E &= -0.62513 \\ F &= -1.150000 \end{aligned}$$

Then the equation to the surface is

$$Y = 28.11678 + 2.15x_1 - 1.02313x_2 + 1.70824x_3 - 0.62513x_4 - 1.15x_5$$

To change into original units

$$\text{put } x_1 = \frac{n}{20} - 1$$

$$x_3 = \frac{p}{20} - 1$$

On simplifying the equation to the quadratic surface is found as

$$Y = 21.458280 + 0.267513n - 0.002563n^2 + 0.205425p - 0.001563p^2 - 0.002375 np.$$

Similarly the equation for wheat can also be obtained.

The method of calculating the standard errors of the fitted constants is also given in detail in the reference cited above.

# RUST-RESISTANT WHEATS FOR MADHYA PRADESH

## II. A NOTE ON RECURRENCE OF WHEAT RUSTS AND THEIR RACES

R. B. EKBOTE and P. K. KAUSHAL

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Wheat is one of the most important food crops of Madhya Pradesh and occupied an area of about 33 lakh acres before the State's reorganisation. The only disease which causes heavy losses to the wheat crop in this State is rust, and its severity and spread vary from year to year. Before the Wheat Breeding Scheme came into operation at Powarkheda, Hoshangabad in June, 1941, there was very meagre knowledge available about the relative recurrence of the different rusts and their races in the then existing State of Madhya Pradesh. All that was available were the results of the analysis of the few rust samples collected during the period 1930-1937, published by Mehta (1940). Races 15, 40 and 42 of the black stem rust (*Puccinia graminis tritici* (Pers.) Erikss and Henn) and 10, 20 and 63 of *Puccinia rubigovera* (Schm.) Erikss and Henn appeared to be common. It therefore, became necessary to undertake a comprehensive survey of the different rusts and their races since the knowledge of their relative occurrence is of primary importance to the breeder.

This survey was undertaken in collaboration with the then officer in charge of the Rust Research Laboratory, Simla, and he has already published the results of the analysis of the rust samples which we had collected from different parts of the State from year to year and forwarded to him (Vasudeva *et al.*, 1955). But this did not give any information on the frequent occurrence and the incidence of each rust, the extent of crop infection in different years and the races which were more common in Madhya Pradesh (pre-reorganised).

### MATERIAL AND METHODS

The information given here is based on year to year observations of the rust affected areas of old Madhya Pradesh consisting of Mahakoshal and Vidarbha regions of the present Madhya Pradesh and Bombay States, respectively, during a period of thirteen years: 1941-42 to 1953-54 (Table I). A number of races were identified. The analysis of rust samples, collected from the affected areas of the State, was carried out at the Rust Research Laboratory, Simla.

The number of samples analysed especially after 1947-48 was too small (Table II). This was due to the occurrence of rust at only a few places after 1947-48. Random samples of rust affected wheat plants were collected for analysis of rust races from the affected areas of the then existing State of Madhya Pradesh. But all samples could not be analysed.

### OBSERVATIONS

The occurrence of the three rusts and their incidence in different years is given in Table II.

The recurrence of physiologic races of different rusts are shown in Tables III and IV.

TABLE I. RESULTS OF ANALYSIS OF RUST SAMPLES AND OBSERVATIONS ON THE INCIDENCE OF RUST AND EXTENT OF ITS INFECTION IN MADHYA PRADESH (PREMERGER)

Kind of rust	Incidence of rust	Extent of infection	Races identified	Weather during the crop season as recorded at Powarkheda
1941-42				
Stem	Moderate	Widespread	15, 34, 42	Dry
Brown	Mild	Sporadic	20, 63	
Yellow	Mild	Rare	A	
1942-43				
Stem	Mild to heavy	Sporadic	15, 40, 42	Belated winter showers
Brown	Traces	Rare	..	
Yellow	Did not occur			
1943-44				
Stem	Heavy	Widespread	15, 40 and 42	Intermittent winter rains
Brown	Mild	Sporadic	20, 63	
Yellow	Mild	Detected at Powarkheda only	19,	
1944-45				
Stem	Mild to heavy	Widespread	15, 21, 40, 42, 53 and 117 (Last two detected for the first time)	An inch of rain in January
Brown	Mild	Sporadic	10, 63 107	
Yellow	Did not occur			
1945-46				
Stem	Traces to mild	Widespread	No samples were collected	Dry
Brown				
Yellow	Did not occur			
1946-47				
Stem	Catastrophic	All over the State	21, 40, 42, 75 117 (B)	Heavy and intermittent winter rains
Brown	Heavy	Widespread	10, 20, 26, 63 107	
Yellow	Did not occur			

TABLE I—*Contd.*

Kinds of rust	Incidence of rust	Extent of infection	Races identified	Weather during the crop season as recorded at Powarkheda
1947-48				
Stem	Moderate to heavy	Confined to northern districts	15, 21, 42, 117 (B)	About two inches of rain in winter
Brown } Yellow }	Did not occur			
1948-49				
Stem	Moderate	Confined to Northern districts	21, 40, 42	About six inches of rain in November followed by clear weather throughout the rest of the season
Brown } Yellow }	Moderate	Sporadic	20, 63	
	Did not occur			
1949-50				
Stem	Traces	Sporadic	21, 42	Dry
Brown } Yellow }	Did not occur			
1950-51				
Stem	Mild to heavy	Sporadic	21, 40, 42	About two inches of rain in December
Brown } Yellow }	Did not occur			
1951-52				
Stem	Traces to heavy	Sporadic	21, 34, 40, 42	An inch of rain in February
Brown } Yellow }	Did not occur			
1952-53				
Stem	Traces to heavy	Sporadic	21, 34, 40, 42	Almost dry
Brown } Yellow }	Did not occur			
1953-54				
Stem	Mild	Sporadic	..	An inch of rain in January
Brown } Yellow }	Did not occur			

TABLE II. RECURRENCE OF THE THREE RUSTS DURING THE THIRTEEN YEARS, 1941-42 TO 1953-54, IN MADHYA PRADESH (PREMERGER)

Rust	Severe	Mild to heavy	Traces to mild	Absent
Black stem	2	6	5	..
Brown	1	0	5	7
Yellow	..	..	2	11

TABLE III. RECURRENCE OF PHYSIOLOGIC RACES OF *PUCCINIA GRAMINIS TRITICI* IN MADHYA PRADESH (PREMERGER)

(Number of samples in which the races were identified)

Year	15 R	21	24 A	34	40 C	42	75 E	117	194 S	Total number of samples analysed
1941-42	5	..	..	2	..	7	..	..	..	14
1942-43	7	..	..	..	5	10	..	..	..	22
1943-44	13	..	..	..	4	12	..	..	..	29
1944-45	3	7	..	..	2	12	..	1	1	26
1945-46	..	..	..	..	..	..	..	..	..	..
1946-47	..	10	..	..	2	14	1	2	..	29
1947-48	3	31	..	..	..	22	..	1	..	57
1948-49	..	1	..	..	1	1	..	..	..	3
1949-50	..	3	..	..	..	2	..	..	..	5
1950-51	..	1	..	..	1	1	..	..	..	3
1951-52	..	1	..	1	1	1	..	..	..	4
1952-53	..	1	..	1	1	1	..	..	..	4
Percentage of occurrence	15.82	28.06	—	2.04	8.67	42.35	0.51	2.04	0.51	196

TABLE IV. RECURRENCE OF PHYSIOLOGIC RACES OF *PUCCINIA RUBICOVERA* IN MADHYA PRADESH (PREMERGER)

(Number of samples in which the races were identified)

Year	10	20	26	63	107	D	Total number of samples analysed
1941-42	..	4	..	3	..	..	7
1942-43	..	..	..	..	..	..	..
1943-44	..	1	..	1	..	..	2
1944-45	1	..	..	1	1	..	3
1945-46	..	..	..	..	..	..	..
1946-47	..	5	1	1	1	1	9
1947-48	..	..	..	..	..	..	..
1948-49	..	3	..	1	..	..	4
1949-50	..	..	..	..	..	..	..
1950-51	..	..	..	..	..	..	..
1951-52	..	1	..	1	..	..	2
Percentage of occurrence	3.7	51.8	3.7	29.6	6.14	3.7	27

The yellow rust was of rare occurrence, and only race A and 19 was detected in two samples sent from Powarkheda during 1941-42 and 1943-44. An estimate of damage to the wheat crop during the two epidemic years 1943-44 and 1946-47 is given below (Table V).

TABLE V. AN ESTIMATE OF DAMAGE OF THE WHEAT CROP BY STEM RUST (*PUCCINIA GRAMINIS TRITICI*) IN THE LAST TWO EPIDEMICS

Area affected in acres	Estimated outturn of rust affected crop in lb. per acre	Outturn per acre estimated from the crop growth	Loss per acre in lb. and rupees	Loss over the entire affected area
<b>1943-44</b>				
10 lakh Approximately	315	630 lb. (normal yield for the affected areas)	315 lb. or Re. 35/- @ 9 lbs. per rupee	Rs. 3.5 crores
<b>1946-47</b>				
28 lakh Over the entire wheat area of old Madhya Pradesh	82	550 lb. (normal for the State)	468 lb. or Re. 58.50 @ 8 lb. per rupee	Rs. 16 crores

It is clear from Table II that the stem rust was of more common occurrence than the brown and yellow rusts; the last was of no consequence in this State. Damage by brown rust was not appreciable as possibly it was masked by the stem rust, which admittedly is the main rust to contend with.

An analysis of the rust samples revealed that races 42, 15, 21 and 40 were more common than others and breeding of rust-resistant varieties must be principally directed against these four races. The other races although relatively unimportant cannot be ignored. So while selecting breeding material for hybridization, resistance to the more commonly occurring races should primarily be looked into along with resistance to other races. As compared to the all-India distribution worked out by Vasudeva *et al.* (1955), the prevalence in Madhya Pradesh has been nearly the same and not different as found by Johnson (1956) in the different geographic areas of Canada. There are no great barriers in the plains of India to prevent the spread of races in different parts.

Even though Mehta (1940) almost ruled out the possibility of sexual propagation of the rust fungus in India, the chances of new races appearing now and then cannot be totally ignored. During the last few years, new races such as 117, 194 (Vasudeva *et al.*, 1955) have been detected. Reappearance of a known race after a period of absence is also conceivable as would be apparent from the occurrence of race 21 after a lapse of many years. Indeed, this race has taken a place next to the most prevalent race 42.

The work in regard to breeding brown rust-resistant strains has not been taken up in Madhya Pradesh, but if and when it is undertaken the information collected through the above survey will be of immense value.

It is apparent from Table V that the loss to the wheat crop was three and sixteen crores of rupees during the epidemic years 1943-44 and 1946-47, respectively. In fact, the estimate errs on the lower side because having regard to the favourable and intermittent rains received during the crop season, the outturn would easily have exceeded the normal yield. But even on the basis of normal yield, the loss in the two epidemics was nearly twenty crores of rupees.

#### ACKNOWLEDGEMENTS

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# A MOSAIC DISEASE OF MAIZE (*ZEA MAYS* L.) IN INDIA

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During the 1952 season, some plants of maize grown in an experimental plot of the Division of Mycology and Plant Pathology, Indian Agricultural Research Institute, New Delhi, were found affected by a mosaic disease. One to two per cent of the plants only showed clear mosaic symptoms. The affected plants were characterised by being somewhat smaller in size and pale green in appearance. The leaves of the diseased plants exhibited prominent mottling, indicative of sugarcane mosaic virus of which maize is considered to be an important host.

So far there has been no report of any virus disease occurring on maize in nature in India. The present work on this virus was, therefore, undertaken with a view to study this virus disease and to ascertain its relationship with the sugarcane mosaic virus.

## MATERIAL AND METHODS

*Transmission:* The maize mosaic virus was found to be readily transmissible by mechanical inoculation and was successfully transmitted in a variety of manners. The methods employed by Matz (1933) and Chona and Rafay (1950) for transmission of sugarcane mosaic virus proved to be quite effective for the transmission of the virus, the percentage of infection generally obtained being about 60 per cent. The virus was also successfully transmitted by Sein's (1930) method by placing a diseased leaf over a young healthy leaf of the central spindle of a test plant and pricking through them a few times with a fine sterilized needle, but the percentage of infection obtained was comparatively low, being less than 20 per cent.

The most convenient and effective method of mechanical inoculation was found to consist of rubbing the youngest leaf to be inoculated with a small piece of sterilized cotton wool dipped in infectious juice and using fine carborundum powder as an abrasive. With this method, the percentage of infection obtained in most of the cases was cent per cent. This method of inoculation was, therefore, followed in all the experiments conducted with maize and grasses having soft leaves. For transmission to sugarcane and grasses with hard leaves, however, the method employed by Chona and Rafay (1950) for inoculation of sugarcane mosaic virus was used.

The juice for inoculation was obtained from the topmost three or four leaves of the young infected maize plants showing prominent symptoms of mosaic according to the method employed by Chona and Rafay (1950).

For inoculation, young maize plants (variety Meerut Yellow) about a week or ten days old, were used for all experiments except where otherwise stated. The mosaic symptoms usually appear on the inoculated plants in 5 to 21 days, the time depending

on weather conditions, being the shortest during the hot summer months. All the experiments were conducted in insect-proof houses.

#### OBSERVATIONS

*Symptoms of the disease in the inoculated plants:* The symptoms in the infected plants are variable, owing probably to the intensity of infection (Fig. 2), but the general background in all the cases is practically the same, i.e., of mosaic mottling, the difference being in the intensity only. The symptoms first appear in the infected plant at the base of the young unfolding leaf, generally in the form of yellow specks, in rows parallel to the long axis of the leaf. The specks usually appear on one side of the leaf midrib, to start with. These specks elongate in the form of chlorotic spindles of varying lengths. They have a tendency to elongate and spread out parallel to the midrib of the leaf. As they elongate, they usually coalesce, and small chlorotic areas are formed on the leaf which result in blotching of the green tissue. In severe cases of infection, light-green areas predominate and the normal green tissue appears in the form of small islands encircled by the light-green tissue (Fig. 1). In the older leaves, there is a tendency for the mosaic mottling to become fainter as they reach maturity.

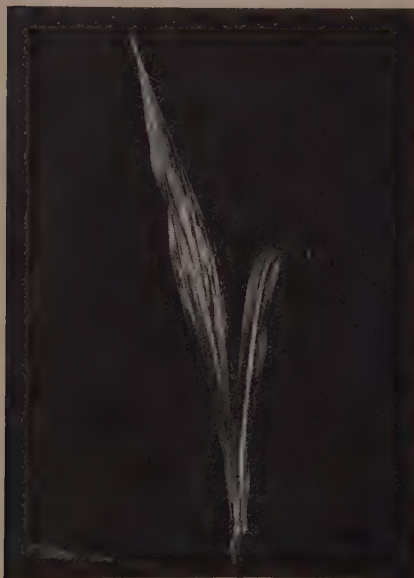


FIG. 1. A MAIZE PLANT ARTIFICIALLY INFECTED WITH THE VIRUS SHOWING SEVERE TYPE OF INFECTION



FIG. 2. MAIZE LEAVES SHOWING VARIATION OF SYMPTOMS

The infected plants are always light-green in colour and are easily distinguishable from healthy plants even from a distance. The infected plants are comparatively short in size, and the reduction is more pronounced in the plants showing severe

infection from the early stages of their growth. The cobs of the diseased plants are usually not well filled.

*Host-range studies:* The host-range studies were made by mechanical inoculations with infectious leaf juice. Maize varieties Meerut Yellow, Pusa Yellow, Kanpur Type 41, Wisconsin 464, Texas 26, Dixie 33, Kansas 1859 and North Carolina 27 were tested, and all of them were found to be readily infected. The seeds of these varieties were obtained from the Botany Division of the Indian Agricultural Research Institute. Among the grasses and millets, it was possible to transmit the virus to *Sorghum vulgare* Pers., *Sorghum sudanense* (Piper) Stapf, *Dactyloctenium aegyptium* (L.) Beauv., *Coix lachryma-jobi* L., *Euchlaena mexicana* Schrad., *Digitaria bifasciculata* Henr., *Setaria verticillata* (L.) Beauv., *Brachiaria ramosa* Stapf., (Fig. 3 and 4) and *Phalaris*



FIG. 3. LEAF OF (A) *Sorghum vulgare* (B) *Coix lachryma-jobi* AND (C) *Sorghum sudanense* ARTIFICIALLY INFECTED WITH THE MAIZE MOSAIC VIRUS

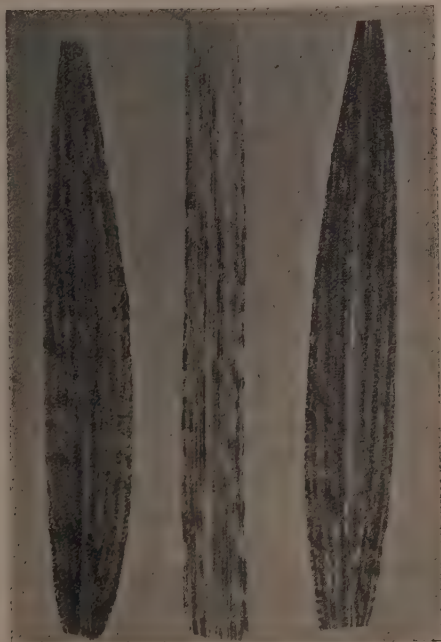


FIG. 4. LEAF OF (A) *Brachiaria ramosa*, (B) *Dactyloctenium aegyptium*, AND (C) *Setaria verticillata* ARTIFICIALLY INFECTED WITH THE MAIZE MOSAIC VIRUS

*minor* Retz. The disease appeared in most of the test plants in about two weeks' time after inoculation, and the symptoms followed practically the same pattern in all the hosts as is described for maize, except the last named host (*Phalaris minor* Retz.) in which the virus was carried symptomlessly. The back-inoculation tests from this host on maize have always given positive results. *Phalaris minor* Retz. is a very common grass in Delhi during the winter, which is the off-season for maize in northern

India, and may thus explain the perpetuation of the virus from one season to the next in the absence of the maize crop. The negative results obtained with some of the grasses and other graminaceous hosts tested are: *Pennisetum typhoides* Stapf. and Hubb., *Pennisetum orientale* Rich., *Pennisetum purpureum* Schum. and Thorn., *Hordeum vulgare* L., *Sorghum halepense* Pers., *Triticum vulgare* Vill., *Imperata cylindrica* (Linn.) P. Beauv., *Eragrostis curvula* (Schrud.) Nees., *Saccharum arundinaceum* Hock. and *Saccharum officinarum* L.

Repeated tests with sugarcane plants have clearly shown that the maize mosaic virus under investigation could not be transmitted to sugarcane. For an artificial transmission, cane varieties Co. 312, Co. 313, Co. 213, Co. 723, Co. 798 and *Surkha Saharanpuri* all of which are known to be susceptible to the sugarcane mosaic virus, were used. The back-inoculation tests carried out on maize with juice extracted from sugarcane plants (Co. 313) previously inoculated with the maize mosaic virus, have also failed to produce any symptoms in the test plants. Besides graminaceous hosts, about 25 other plant species belonging to Solanaceae, Cucurbitaceae, Umbelliferae and Leguminosae were inoculated, but none of the plants belonging to these families were found to be susceptible to the virus. It appears that the host-range of the virus is restricted to a few members of the family Graminae only.

*Physical properties of the virus*: Studies on the physical properties of the virus were carried out to find out its relationship with other sap-transmissible viruses reported to infect maize. For this purpose, the thermal inactivation point was determined by heating freshly extracted juice of infected maize leaves. It has been found that the virus retains its infectivity even after heating at 50°C for ten minutes, but remains no longer infective when heated for the same period at 55°C. At room temperature (28 to 32°C.), the virus in the expressed sap remains viable for 16 hours, but is rendered innocuous after 24 hours of storage. The juice retains its infectivity when diluted to 1:50 with sterilized distilled water, but loses its infectivity completely at dilutions 1:100 or beyond.

*Insect transmission*: Insect transmission tests were carried out through the agency of aphids. The insects used for the purpose were *Aphis maidis* Fitch., *Macrosiphum granarium* Kirby and *Aphis gossypii* Glover. *Aphis maidis* and *Macrosiphum granarium* are found infesting several graminaceous crops as also a large number of grasses. Both these aphids have been recorded on maize from Delhi (Ghulam Ullah, 1940). *A. maidis* is known to be a very important vector of the sugarcane mosaic virus throughout the world.

*Aphis gossypii* is extremely polyphagous in habit, and is found colonizing on a large number of cultivated as well as wild plants. This insect is known to transmit a large number of plant virus diseases and has also been reported to be the vector of maize mosaic from the Philippines (1949).

Healthy colonies of insects were reared on plants which are immune to the maize mosaic virus. *Aphis maidis* was colonized on barley, *Macrosiphum granarium* on tobacco and radish, and *Aphis gossypii* on chilli plants. The plants on which insects were reared were always raised and kept inside insect-proof cages.

The preliminary insect transmission tests were carried out to determine if any or all of these insects could act as vectors of this virus. For this purpose, a large number

of these insects was transferred separately on diseased maize plants and allowed to feed there for a few hours.

In these tests, no starvation period was allowed to the aphids before they were given a feeding on diseased plants. In the later confirmatory tests, the insects in all cases were starved for a certain period before they were transferred to diseased plants for infection-feeding. The period of starvation usually ranged from half an hour to one hour.

After the period of feeding on diseased plants, 10-20 aphids were transferred immediately with the help of a sterilized camel-hair brush to healthy maize seedlings raised in six-inch pots in the insect-proof house. The insects were allowed to feed overnight on the test plants. The insects were then removed from the test plants and the plants immediately sprayed with nicotine sulphate solution.

It was observed that the insects have a tendency to collect inside the spindle formed by the partially open leaf, and prefer to feed on the tender young, emerging leaf inside it.

The symptoms of the disease generally take 10-28 days to appear after the test feeding of the insects, depending upon the seasonal temperature, the incubation period being shorter during April and September when the average daily temperature is 91.5°F and 95.9°F, respectively. The results of the various transmission tests obtained with each of the three aphids are shown in Table I.

TABLE II. INSECT TRANSMISSION TESTS WITH *A. MAIDIS*, *M. GRANARIUM* AND *APHIS GOSYPII*

Time of transmission tests	<i>Aphis maidis</i>			<i>Macrosiphum granarium</i>			<i>Aphis gossypii</i>		
	No. of plants		Per cent infection	No. of plants		Per cent infection	No. of plants		Per cent infection
	Inoculated	Infected		Inoculated	Infected		Inoculated	Infected	
January '53 to April '53	120	8	6.6	18	2	11.1	24	4	16.6
September '53 to November '53	..	..	..	..	..	..	39	9	23.07
January '54 to April '54	50	4	8.0	32	12	37.5	..	..	..

In the tests which were carried out from September, 1953 onwards, all the insects employed were invariably starved for at least half an hour before they were given infection-feeding on mosaic-infected maize plants. On comparing the percentage of infection obtained with each species of aphids, it would be seen (Table I) that the practice of giving a starvation period seems to have increased appreciably the efficiency of the two aphids, namely, *A. gossypii* and *Macrosiphum granarium*. These two insects have also proved to be more effective vectors of this virus than *Aphis maidis*, which is universally recognized as the most important vector of the sugarcane mosaic virus.

*Seed transmission:* Tests carried out with 500 seeds collected from maize plants artificially infected with the virus under insect-proof conditions failed to give any evidence to show that the virus was seed-transmissible.

## DISCUSSION

Brandes (1919) reported maize among the hosts of the sugarcane mosaic virus from Puerto Rico. From the symptoms of the disease on maize plants growing in between the rows of mosaic-affected cane stubbles, which were identical with sugarcane mosaic, he inferred that maize mosaic and sugarcane mosaic were identical. Later, he (1920) described maize mosaic and established the corn aphid (*Aphis maidis*) as its vector, which is also the vector of the sugarcane mosaic virus. But in these transmission tests of the disease to maize, the inoculum used was from sorghum plants infected with the sugarcane mosaic virus and not the naturally mosaic-infected plants of maize.

Kunkel (1922) transmitted maize mosaic in Hawaii from maize to maize by means of the corn leaf-hopper, *Peregrinus maidis*, but was not able to transmit it from maize to sugarcane. Stahl (1929) reported a serious disease of maize in Cuba which is stated to resemble the well-known mosaic disease of sugarcane in many respects, but is distinct from it. He named the disease as 'corn stripe' and was able to transmit it by *Peregrinus maidis* to maize but not to sugarcane. *Aphis maidis* was, however, found to be unable to transmit the disease.

Shepherd (1929) from Reunion Island, Briton Jones (1933) from Trinidad and Storey (1936) from East Africa have also described an identical disease of maize transmitted by *Peregrinus maidis*. There seems to be no relationship between these and the maize mosaic virus under investigation, as they are all leaf-hopper transmitted and not sap-transmissible.

Storey (1927), investigating virus diseases of sugarcane and related plants in South Africa, observed a strain of mosaic in Transvaal on maize, *Sorghum arundinaceum* Stapf and *Sorghum vulgare* L., which, he says, is different from sugarcane mosaic, although the symptoms that it produces on these plants are indistinguishable from those produced by the sugarcane mosaic virus. His inference was based on field observations in those areas where several small plots of sugarcane varieties known to be susceptible remained free of mosaic though grown adjacent to aphid-infested diseased sorghum and maize. In a subsequent paper (1929), Storey experimentally transferred the disease to maize by *A. maidis*, but all attempts to transfer it to sugarcane remained unsuccessful.

Lawas and Fernandez (1949) reported a mosaic disease of maize from the Philippine Islands. The causal virus is sap-inoculable, has T.D.P. at 50-55°C., longevity at room temperature 24 hours, and dilution-end-point as 1:10. In all these aspects, it closely resembles the maize mosaic virus under investigation. Furthermore, the disease is reported to be transmitted both by *A. gossypii* and *A. maidis* to maize and that *A. gossypii* is a more effective vector than *A. maidis*, this is also true in the case of the present virus. The authors, however, considered it as identical with the sugarcane mosaic virus. Possibly, the symptoms on maize and the physical properties of the virus, which are similar to the sugarcane mosaic virus, have been made the basis of their conclusion. But no experimental proof of the transmission of the maize mosaic virus to sugarcane either by sap-inoculation or by insects has been presented.

Recently, a mosaic disease of sweet corn has been reported by Finley (1954) from the U.S.A. It, however, differs in its physical properties from the maize mosaic virus described here. The sweet corn mosaic has a thermal-death-point of 45-50°C. and dilution-end-point at 1:10,000. In host-range studies also, the sweet corn mosaic virus has been shown to infect barley and wheat, while the maize mosaic virus under study does not infect these hosts.

*Cucumis* virus 1 of Smith (1937) has also been reported to infect maize and some other Monocotyledonous hosts, but it differs widely in its physical properties and host-range from the virus under discussion. The present virus is not infective to celery or cucurbits which are readily infected by the *Cucumis* virus.

The maize mosaic virus compares favourably with Storey's Transvaal grass mosaic virus in respect of its vector *Aphis maidis*, and its non-transmissibility to sugarcane. But in the absence of any available data regarding its physical and other properties, it is not possible to say whether the two viruses are identical.

In view of the above, the virus under investigation is considered as distinct from all the known viruses on maize, described so far or any strain of the sugarcane mosaic virus.

#### SUMMARY

A sap-inoculable mosaic disease of maize has been described which is distinct from sugarcane mosaic.

The host-range of the virus includes maize (*Zea mays* L.) and its several varieties, *Sorghum vulgare* Pers., *Sorghum sudanense* (Piper) Stapf, *Dactyloctenium aegyptium* (L.) Beauv., *Coix lachryma-jobi* L., *Euchlaena mexicana* Schrad., *Digitaria bifasciculata* Henr., *Setaria verticillata* (L.) Beauv., and *Brachiaria ramosa* Stapf., and also *Phalaris minor* Retz., a winter grass, as a symptomless carrier.

The thermal-death-point of the virus lies at 50-55°C. and the dilution-end-point between 1:50 and 1:100. Its longevity at room temperature (28-32°C.) is 16 hours.

The virus is transmitted to maize by three species of aphids, namely, *Aphis maidis* Fitch, *Aphis gossypii* Glover and *Macrosiphum granarium* Kirby. The last two are more effective as its vectors.

The virus is not seed-transmissible.

The virus is distinct from any other described so far on maize though it resembles in certain respects Storey's Transvaal Grass mosaic virus as also the maize mosaic virus reported from the Philippines by Lawas and Fernandez.

#### ACKNOWLEDGEMENTS

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# BLIGHT OF BLACK GRAM CAUSED BY *SCLEROTINIA SCLEROTIORUM* (LIB.) DE BARY

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Black-gram (*Phaseolus mungo*) is extensively cultivated in Assam. A severe blight of the crop was recorded in the farm of the Assam Agricultural College, during 1955-56. The host of fungi so far recorded on *Phaseolus* does not seem to include the organism recorded in that blast. Work on *Sclerotinia sclerotiorum* (Lib.) de Bary have, however, been done in India by Shaw and Ajrekar (1915), Joshi (1924), Kheshuwalla (1934) and Mundkur (1934). From these studies, it appears that the fungus has a very wide host range and *Phaseolus mungo* is an addition to it. The following studies were undertaken to investigate this new disease of the crop.

## OBSERVATIONS

### *Symptoms on the host*

All parts of the plant above the ground, are attacked by the fungus. The stem, at first, develops a light brown patch, the fungus then spreads rapidly and destroys the internal tissues which are replaced by the mycelium. As the disease progresses, the colour of the stem and the branches change to greyish white. The mycelium forms white mass on their surfaces. Finally, the stem and branches become hollow



FIG. 1.  
A. HEALTHY PLANT  
B. DISEASED PLANT

and brittle. Large black sclerotia are formed abundantly both outside and inside the stem and branches. The leaves lose colour and become flacid. The fungus forms white hyphal mass and sclerotia on the surface and, gradually, the leaves begin to wilt and droop. Mostly all the leaves fall off or very few of them are left on the plant. The pods dry up completely and the sclerotia of the fungus are formed on the surface and inside the pods in place of seeds.

In the field, the plants die, forming large patches of greyish white colour which mark out distinct blighted areas within the green field.



FIG. 2. BLACK GRAM PLANTS ATTACHED BY *Sclerotinia sclerotiorum* IN THE FIELD: HEALTHY AND DISEASED PLANT: A-HEALTHY PLANTS, B-A BLIGHTED PATCH.

#### *The causal organism*

The fungus was cultured by transferring diseased fragments which were properly surface sterilised before planting. The organism was also grown by transferring the sclerotia which were washed in 1:1000 mercuric chloride, dipped in alcohol and flamed before transferring to media.

The fungus was grown on potato-dextrose-agar, oatmeal-agar, malt-agar, peptone-dextrose-agar and Dox's media. It was found to grow well at a temperature between 20-25° C. The growth (of the fungus) was very good on oatmeal-agar, but it also grew quite well in both P.D.A. and Dox's media. Growth in the other two media was very thin and scanty. The mycelium is hyaline, septate and branched, being about 9 $\mu$  broad on average.

*Sclerotia*: The black sclerotia are produced in culture within three to five days. The production of sclerotia is also best in oatmeal-agar. Only a few smaller sclerotia were produced in malt-agar while only sclerotial initiations, but no sclerotia, were produced in peptone-dextrose-agar medium. The sclerotia are large, irregular in shape—mostly roundish and 2.5 mm. in diameter. The cylindrical sclerotia, formed inside the stem of the host, may, however, be up to 2 cm. in length.

*Apothecia*: The sclerotia collected from the host, in the field, were placed on moist sand in petri dishes on the 16th January, 1956 and kept under humid conditions. Sterilised water was sprinkled over them at regular intervals. These sclerotia began to germinate by producing apothecial stalks in the first week of November, 1956. The apothecia matured by the 25th November, 1956, i.e. after overwintering or a period of rest. But the sclerotia produced in culture medium (oatmeal-agar), in 250 cc. conical flasks, between the 15 to 25th December, 1956, began to germinate in the first week of January, 1957, i.e. in the same winter. The sclerotia produced

in culture during summer, however, did not germinate before the next winter. This can be accounted for by the results of Kheshwalla (1934) and Mundkur (1934) who stated that low temperature is one of the factors for production of apothecial stalks.

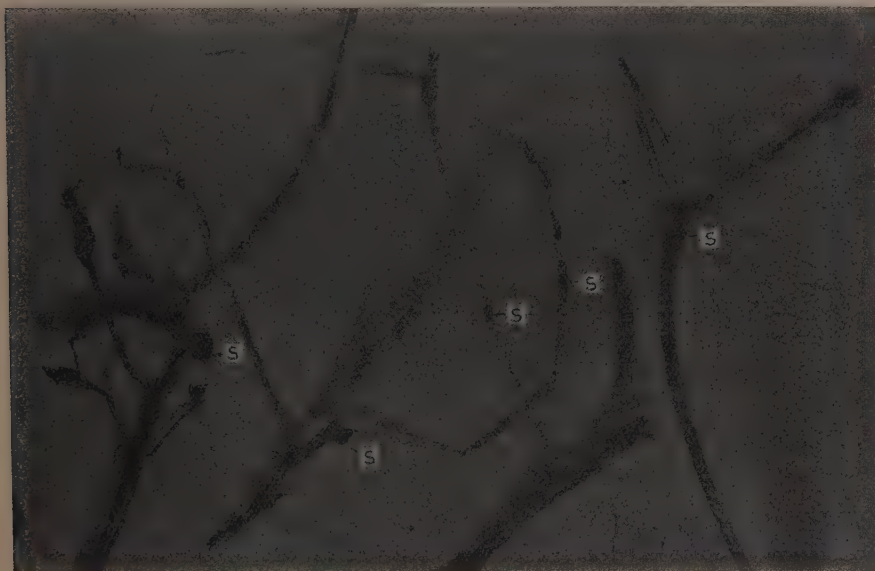


FIG. 3. DISEASED STEM SHOWING THE SCLEROTIA, S-SCLEROTIA

Several apothecial stalks may arise from a single sclerotiorum. All of them, however, may not develop into mature apothecia. The apothecia are brown, stipitate, disk-shaped and up to 3.5 cm. in length. The asci are cylindrical, hyaline, 8-spored,  $97.5-165\mu \times 6-10\mu$  and intermingled with filiform paraphyses. The ascospores are hyaline, ovoid or elliptical, unicellular, uniscriate,  $7-13\mu$  in length and  $4-6.5\mu$  in breadth. The ascospores are puffed out in visible dusts when the mature apothecia are disturbed by air.

*Microconidia*: Microconidia are produced by the fungus in culture, particularly when the culture is old. They measure about  $3.4\mu$  in diameter in average and are roundish in shape.

No *Botrytis* or other conidial stage has been formed by the fungus. Pethybridge (1915-16) and Buchwald (1949) have discussed the relation of the *Botrytis* conidia with *Sclerotinia* and have shown that the conidial stage is absent in *Sclerotinia*.

*Identity of the fungus*: From the foregoing studies it appears that the present organism agrees in all respects with *Sclerotinia sclerotiorum* (Lib.) de Bary as described in Saccardo's *Sylloge Fungorum* or by Smith (1900), Ramsey (1925), Kheshwalla (1934) and Mundkur (1934).



FIG. 4. A & B. PRODUCTION OF APOTHECIA IN THE LABORATORY

#### INOCULATION EXPERIMENTS

Sclerotia, mycelia as well as ascospores were used as inocula. Black-gram seeds collected from a disease-free area, were sown in pots and inoculation was done when the seedlings were about six inches high. Eighteen seedlings were divided into three lots of six seedlings each. These three lots were inoculated with mycelia, sclerotia and ascospores respectively. Of the six seedlings, in each of the two lots to be inoculated with mycelia and sclerotia respectively, three were inoculated by making slight incisions with a sterilised scalpel in the collar region while the other three were inoculated without wounds. Inoculation with the ascospores were made on the leaves of the third lot, three of which were again slightly incised with needle on the leaves. Twelve seedlings, six of which were slightly wounded, served as controls.

All the inoculated seedlings took infection within seven days. The seedlings also showed the characteristic symptoms of the disease. The organism was isolated from the infected seedlings and compared with the original culture.



FIG. 5. INOCULATED BLACK-GRAM SEEDLING  
SHOWING THE DISEASE AND WHITE HYPHAL  
MASSES OF THE FUNGUS

TABLE I. INOCULATION EXPERIMENT ON BLACK-GRAM SEEDLINGS

Inoculum	Where inoculated	Inoculated (No.)	Date of inoculation	Date of infection	No. took infection	Control
Mycelia	wounded collar	3	30th Nov. 1956	4th Dec. 1956	3	3
-do-	unwounded collar	3	-do-	5th Dec. 1956	3	3
Sclerotia	wounded collar	3	-do-	-do-	3	All the Seedlings remained unaffected
-do-	unwounded collar	3	-do-	-do-	3	
Ascospores	wounded leaves	3	-do-	-do-	3	3
-do-	unwounded leaves	3	-do-	6th Dec. 1956	3	3

#### *Transmission and control*

The sclerotia of the fungus are extensively formed on the diseased plants and within the pods in place of seeds. Some of the sclerotia are collected with the seeds and some fall off on the ground. During winter, when the seeds are sown and the seedlings grow up, the apothecia spring out from the sclerotia remaining either on the soil or with the seeds. This has been confirmed by actual observation and collection of apothecia, with sclerotia of the fungus, during winter from the field which was affected by the disease in the previous season. The mature apothecia will blow out the ascospores in large masses which will then infect the new crop. Thus, the sclerotia seem to be the main source of inoculum for the subsequent year. The secondary spread of the disease in the field may, however, be due to contact as the plants grow very closely.

The mode of transmission, as observed, suggest the following ways of cultural operations for preventing the disease. Firstly, the seeds from a diseased area should

not be saved for future sowings, and secondly, the crop should not be raised in the same area where the disease had occurred in the previous season. The sclerotia left on soil for two years have been found to lose their viability and hence a rotation of two years may also be practised. It would be helpful to rogue out diseased plants and burn them.

#### SUMMARY

*Sclerotinia sclerotiorum* (Lib.) de Bary causes a blight of *Phaseolus mungo* in Assam. The fungus does not produce a *Botrytis* stage but a microconidial state is present. The perfect stage of the fungus, with fully matured asci, was found and it was seen that low temperature is a necessary factor for the production of the apothecial stalks. Infection of the host can be brought about by mycelia, sclerotia or ascospores through wounds or without wounds. The disease is mainly transmitted by the sclerotia, falling off on the ground or collected with the seeds, from the diseased plants.

#### ACKNOWLEDGEMENTS

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# OBSERVATIONS ON THE INCIDENCE OF THE SPIRAL BORER—*AGRILUS ACUTUS* THUNB. (COL., BUPRESTIDAE) IN *HIBISCUS CANNABINUS* AND *H. SABDARIFFA*

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*Hibiscus cannabinus* (mesta) and *H. sabdariffa* (roselle) have attained importance as substitutes for jute in India after partition. Adaptability of these crops to grow in areas unsuitable for jute and their ability to go as a mixture with jute during spinning in jute mills, have induced their cultivation on an increased scale.

Increased cultivation has, however, resulted in the introduction of new pests and diseases. The spiral borer, *Agrilus acutus*, is a new introduction to these crops (*H. cannabinus* and *H. sabdariffa*) in India (Dutt and Mitra, 1954; Dutt and Bhattacharjee, 1957). The pest has, by now, firmly established itself on these crops, particularly on *H. cannabinus*; and its incidence is now a regular annual feature. It generally attacks during the advanced stage of growth of the crop when loss to the plant population is rather serious.

Recently, a sporadic incidence of the pest has also been recorded on *Corchorus olitorius*, the tossa jute variety of commerce, and it is almost certain that the pest has been introduced to jute from its primary host-*H. cannabinus*. Leefmans (1922), who reported the species from Buitenzorg (Bogor) as a serious pest of *H. cannabinus* (Java jute), remarked that *Agrilus acutus* is a native of Java and Sumatra.

The present paper deals with the incidence of the pest, particularly, in relation to the time of sowing of the two species of *Hibiscus* and their varieties. Wallis (1948) observed that potatoes planted in April are subject to more attack by psyllid, while Broadbent *et al.* (1952) reported highest aphid population in earlier planted potatoes. Jacobson and Farstad (1952) pointed out that the average number of eggs laid per stem by wheat stem sawfly increases progressively as the seeding time advances. Time of sowing may as well influence the incidence of *Agrilus acutus* on *H. cannabinus* and *H. sabdariffa*. Evaluation of susceptibility of types under these two species would also be an additional aid in dealing with the pest and these aspects have been experimented upon under the field conditions.

## MATERIAL AND METHODS

For a study of incidence of *A. acutus*, with reference to time of sowing, field experiments were conducted during 1955-56 season with *H. cannabinus* and *H. sabdariffa* as the host material. Experimental layouts in the field were of randomised block design. There were eight different treatments or dates of sowing with four replications for each of the trials conducted with *H. cannabinus* (MT-15) and *H. sabdariffa* (RT-1). Sowings were done at an interval of about a fortnight beginning from the 1st April

and ending on the 8th July. Monthly observations on the incidence of the pest were recorded from samples, selected at random, approximately representing 16 per cent area, splitted into suitable smaller units, of each effective plot, after elimination of one foot border all around. Plot size was 180 sq. ft. (15 ft.  $\times$  12 ft.).

Separate trials, to determine the susceptibility of different varieties of *H. cannabinus* and *H. sabdariffa* to the incidences of the pest, were carried out during 1955-56 and 1956-57 seasons. In the trial with *H. cannabinus*, there were six treatments or varieties with four replications. Plot size was 150 sq. ft. (15 ft.  $\times$  10 ft.). In *H. sabdariffa* trial, there were four varieties which were replicated six times. Plot size was 540 sq. ft. (30 ft.  $\times$  18 ft.). Monthly observations on the pest-incidence were recorded from each plot using the same method of sampling as in the previous experiments. For the purpose of analysis of variance, incidence figures were converted into percentages. Subsequent transformation of the incidence per cent or variates was made using the formula:

$$y = \sqrt{p + \frac{1}{2}}$$

$$\text{or } y = s_r \sqrt{p}$$

where,  $p$  = original incidence per cent,

$y$  = transformed variate.

#### OBSERVATIONS

*Mature larva and gall formation:* Damage is done by the borer larva of the pest by inducing development of a gall on the stem and damaging the fibre at that region (Figs. 1 and 2). It is interesting that a prominent and elongated gall is formed in

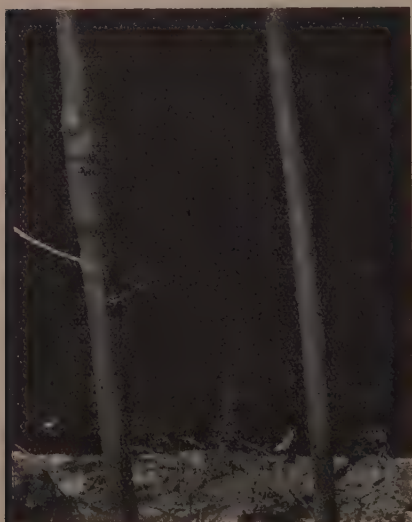


FIG. 1. PHOTOGRAPH OF A GALL ON THE STEM OF *H. cannabinus*.

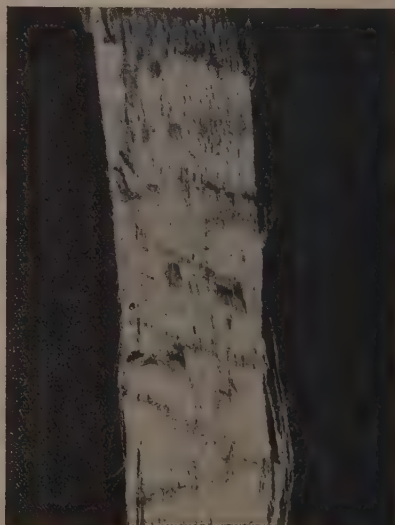


FIG. 2. PHOTOGRAPH SHOWING THE CUT FIBRES AT THE LEVEL OF THE GALL IN *H. cannabinus*.

almost all cases of infested plants of *H. cannabinus* frequently resulting in breaks (Fig. 3) at the level of the gall when there is strong wind. Dutt and Mitra (1954) have observed that galls are usually formed towards the basal region of the stem of *H. cannabinus* and in case of breaks, the entire plant is lost. In almost all cases of affected plants, some fibres remain attached to the stick even after extraction of fibre after retting (Fig. 4). In *H. sabdariffa* gall is not usually formed. Galls varying in length from 9 cm. to 15 cm. are frequently found in *H. cannabinus* (Table I).

TABLE I. DISTRIBUTION OF GALL IN DIFFERENT LENGTH CLASSES

Length (in cm.)	Number	Per cent
< 3	Nil	..
3-6	12	4.56
6.1-9	25	9.50
9.1-12	61	23.23
12.1-15	80	30.41
15.1-18	35	13.30
18.1-21	23	8.74
21.1-24	15	5.70
24.1-27	6	2.28
27.1-30	6	2.28
> 30	Nil	..
Total	263	100

Examination of larvae in the region of the gall and observations on the distribution of emergence hole of the adult on the stem of *H. cannabinus* revealed the presence of fully grown or mature larvae and the exit holes in the vicinity of the gall (Tables II and III).

TABLE II. LARVAL LENGTH IN THE REGION OF GALL

Length (in cm.)	Number	Per cent
< 1	1	2
1-1.5	25	50
1.6-2	22	44
> 2	2	4
Total	50	100

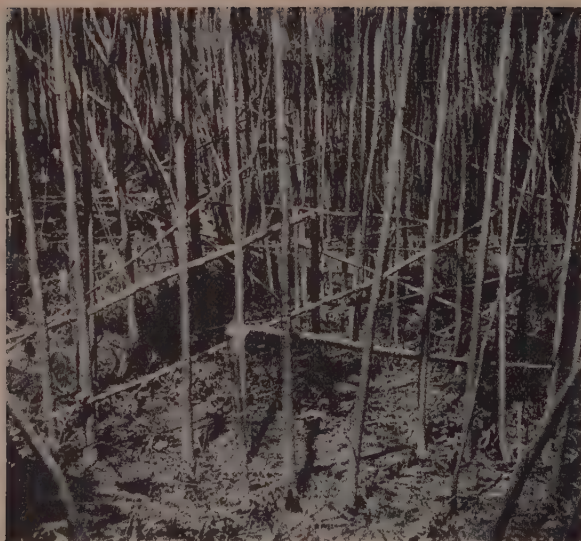


FIG. 3. PHOTOGRAPH OF A HEAVILY INFESTED PLOT OF *H. cannabina* SHOWING BREAKAGES AT THE LEVEL OF GALL AFTER STRONG WIND



FIG. 4. EMERGENCE HOLE OF *A. acutus* ON THE STEM OF *H. cannabina* AFTER EXTRACTION OF FIBRE. SOME FIBRES REMAIN ATTACHED TO THE STICK AT THE LEVEL OF THE GALL.

Full grown larvae usually measure 1.5 cm. in length on average. Presence of such mature larvae and emergence hole of adult near the region of the gall indicates an association of the late larval stage with the development of gall. The larva does considerable wandering upward and downward before it induces development of gall and no evidence of geotropism is noted though Frost (1942) reported association of geotropism in some species of *Agrilus*, viz. positive geotropism in cases of *A. anxius* and *A. bilineatus* and negative geotropism in case of *A. ruficollis*.

TABLE III. DISTRIBUTION OF EMERGENCE HOLE ON THE STEM OF *H. CANNABINUS*

Classes where emergence hole is found on the stem	Number	Per cent
> 8 cm. above gall	1	1.45
< 8 cm. above gall	21	30.43
On the gall	35	50.73
(i) Upper region	(i) 16	(i) 23.19
(ii) Middle "	(ii) 14	(ii) 20.29
(iii) Lower "	(iii) 5	(iii) 7.25
< 8 cm. below gall	11	15.94
> 8 cm. below gall	1	1.45
Total	69	100

Emergence holes (Fig. 4) are usually found on the gall or near about, either above or below it (Table III). Presence of emergence hole at a distance more than 8 cm. from the gall indicates that the borer immediately before prepupal stage is not associated with gall formation.

Observations made on this stage of the borer show that it tunnels deep in the woody tissue immediately before making the pupal chamber. Terminus of this tunnel, leading to the pupal chamber or the emergence hole of the adult amounting to nearly 17 per cent of the total, ends below the level of the gall; about 32 per cent above while the rest 51 per cent approximately has been found on the body of the gall itself.

Distribution of emergence holes (Table III), however, indicates, the possible larval movement while initiating the development of gall. The borer has to travel previously through the region of the stem where the gall is formed for initiating its development. Emergence hole below the level of the gall indicates that the larva has travelled downward and during the travel has induced development of gall. Similarly, emergence hole above the level of the gall implies that the larva has previously travelled upward. In cases, where emergence hole is found in the middle region of of the gall, the explanation that the larva has initiated development of gall while travelling downward does not hold good for the portion of gall below the level of the emergence hole. Similar explanation that the larva has induced gall development while travelling upward cannot explain the initiation of gall above the level of emergence hole. Besides, it is evident from Table III that the emergence hole may be found at a distance near about 8 cm. away from the gall, i.e. the borer does not induce gall formation during the journey of last 8 cm. approximately leading to the pupal chamber. Thus in cases where emergence hole is found on the gall, the length of which usually lies between 9 cm. to 15 cm., the gall formation was induced by the borer during its previous journey through this region followed by a reverse journey leading to the pupal chamber and the exit hole. It is thus apparent that even though such reverse order of travel, to the extent of about 51 per cent approximately by the mature larva is quite frequent, upward or downward journeys are also common indicating its independence of geotropism.

*Effect of variations in the time of sowing on incidence:* Observations from each treatment of the trial with different dates of sowing were recorded upto the fourth month stage of crop growth in case of *H. cannabinus* starting one month after germination. In case of *H. sabdariffa*, observations were continued upto the fifth month stage because of longer vegetative growth period of the crop. It may be seen from Table IV that the incidence of the pest in *H. cannabinus* sown on the 15th April, 1955 was significantly higher than other treatments during the fourth month's stage of growth. April sown crop, however, recorded higher incidence of the pest. Incidence tends to decrease gradually in crops sown during periods succeeding the month of April.

It is interesting to note that, treatments remaining the same, the incidence of the pest remains at much lower level in *H. sabdariffa* in comparison to that of *H. cannabinus*. *H. sabdariffa* recorded higher incidence during the fifth month stage of growth. *H. cannabinus* having shorter vegetative growth period is harvested by then. It may be seen from Table V that the April-sown crop become comparatively more liable to

damage. The crop sown on the 15th April, 1955 recorded the highest incidence during the fifth month stage of growth. During the earlier month, the same treatment came within the critical group showing maximum incidence.

TABLE IV. EXTENT OF ATTACK BY *A. ACUTUS* IN *H. CANNABINUS* SOWN DURING DIFFERENT PERIODS (1955-56)

Treatments (Dates of sowing)	Infestation during different periods in transformed scale		
	1st-2nd month	3rd month	4th month
A. 1-4-55	0.00	..	11.57
B. 15-4-55	0.00	..	24.28
C. 29-4-55	0.00	..	15.70
D. 13-5-55	0.00	..	8.35
E. 27-5-55	0.00	..	5.97
F. 10-6-55	0.00	..	3.60
G. 24-6-55	0.00	..	..
H. 8-7-55	0.00	..	..
P			0.01
C. D.			7.24

TABLE V. EXTENT OF ATTACK BY *A. ACUTUS* IN *H. SABDARIFFA* SOWN DURING DIFFERENT PERIODS (1955-56)

Treatments (Dates of sowing)	Infestation during different periods in transformed scale		
	1st-3rd months	4th month	5th month
A. 1-4-55	0.00	2.67	7.67
B. 15-4-55	0.00	5.02	8.59
C. 29-4-55	0.00	5.82	3.89
D. 13-5-55	0.00	1.83	6.61
E. 27-5-55	0.00	2.92	0.00
F. 10-6-55	0.00	1.33	4.76
G. 24-6-55	0.00	0.00	..
H. 8-7-55	0.00	0.05	..
P	..	0.05	0.05
C. D.	..	3.39	4.64

*Variation in incidence due to varieties:* Different varieties of *H. cannabinus* and *H. sabdariffa* were tested in field trials for assessment of their varietal susceptibility. Because of late sowing of the trials due to weather condition, incidences were considerably low. Six varieties of *H. cannabinus* were used for the purpose in the trial carried out during 1955-56 season. Of the six varieties, MT-15 was isolated from an indigenous material at Jute Agricultural Research Institute while others, viz. MT-129, MT-166, MT-102, MT-128 and MT-150 were exotic types. Monthly observations were recorded from each plot from samples selected at random as mentioned before. No incidence of the pest was recorded in any of the varieties during the first-month growth period. In subsequent stages of growth during the second and third month the difference in incidence between varieties were not significant. Difference was, however, significant at five per cent level during the fourth month stage of growth. The variety MT-15 however, showed consistently lowest incidence in all stages of growth (Table VI).

TABLE VI. VARIATION OF INCIDENCE OF *A. ACUTUS* IN DIFFERENT VARIETIES OF *H. CANNABINUS* (1955-56)

Date of sowing June 3, 1955

Treatments (varieties)	Infestation during different periods in transformed scale			
	1st month	2nd month	3rd month	4th month
A. MT-129	0.0000	1.3371	1.4128	2.1639
B. MT-128	0.0000	1.0859	1.4990	1.7577
C. MT-102	0.0000	0.9831	1.6886	2.0748
D. MT-166	0.0000	1.5145	1.7823	1.6046
E. MT-150	0.0000	1.3628	1.9552	2.2325
F. MT-15	0.0000	0.9589	1.1725	1.1988
P		Large	Large	0.05
C. D.				0.6234

The trial was repeated during 1956-57 and no incidence was recorded till the fourth month stage of growth when the lowest infestation was recorded in the variety MT-15 as in the previous year and as shown in Table VII.

TABLE VII. VARIATION IN THE INCIDENCE OF *A. ACUTUS* IN DIFFERENT VARIETIES OF *H. CANNABINUS* (1956-57)

Date of sowing May 27, 1956

Treatments (varieties)	Infestation in transformed scale	
	1st-3rd month	4th month
A. MT-129	0.0000	1.8537
B. MT-128	0.0000	1.7716
C. MT-102	0.0000	1.6783
D. MT-166	0.0000	1.5683
E. MT-150	0.0000	1.3321
F. MT-15	0.0000	0.8592
P.		0.01
C.D.		0.4951

In case of *H. sabdariffa*, four varieties, viz. *altissima*, RT-2, RT-26 and RT-1 were used in the field trial and monthly observations recorded as in *H. cannabinus*. No incidence was recorded in any of the varieties during the first to the third month stages of growth. The differences in incidence was significant during the fifth month stage of growth. Though the variety RT-1 showed minimum infestation, but statistically was at par with variety *altissima*, the later one, however, came within the critical group showing higher incidences as shown in Table VIII.

TABLE VIII. VARIATION OF *AGRILUS* INCIDENCE IN DIFFERENT VARIETIES OF *H. SABDARIFFA* (1955-56)

Date of sowing June 7, 1955

Treatments (varieties)	Infestation during different periods in transformed scale		
	1st-3rd month	4th month	5th month
A. <i>Altissima</i>	0.0000	1.1483	1.3066
B. RT-2	0.0000	1.1145	1.4713
C. RT-26	0.0000	1.1917	1.4056
D. RT-1	0.0000	1.0358	1.1069
P		Large	0.05
C.D.			0.2208

On repeating the trial in the following season (1956-57) the incidence was observed in all the varieties during the fifth month stage of growth but the difference was not significant though RT-1 showed the minimum infestation (Table IX).

TABLE IX. VARIATION OF *AGRILUS* INCIDENCE IN DIFFERENT VARIETIES OF *H. SABDARIFFA* (1956-57)

Date of sowing June 14, 1956

Treatments (varieties)	Infestation during different periods in transformed scale	
	1st-4th month	5th month
A. <i>Altissima</i>	0.0000	1.7106
B. RT-2	0.0000	1.5520
C. RT-26	0.0000	1.6242
D. RT-1	0.0000	1.4834
P		Large
C.D.		..

# SUMMARY

*Agrilus acutus* is a serious pest of *Hibiscus cannabinus* and also attacks *H. sabdariffa*. It attacks these crops when they approach maturity and induces development of an elongated gall in almost all affected plants of *H. cannabinus*. In *H. sabdariffa* galls are not usually formed. The gall in *H. cannabinus* is usually 9 to 15 cm. long, the range being 3 to 30 cm. Late larval stage initiates the development of gall. The last phase of the larval stage, when it tunnels deep into the woody tissue leading to pupal chamber, is not associated with gall formation. While initiating development of gall, the borer larva may travel either downward or upward indicating its independence of geotropism, followed in about 51 per cent cases by a reverse journey on its way leading to the pupal chamber through inner woody tissues. With variation in the time of sowing of both *H. cannabinus* and *H. sabdariffa*, incidence of the pest is also found to vary. Within the different times of experimental sowing from April to 1st week of July, it has been found that crops sown during April usually get more infestation. Incidence tends to decrease gradually in crops sown during period succeeding the month of April.

Of the six different varieties of *H. cannabinus* tested for their relative susceptibility to the pest, MT-15 was found to be least susceptible than others. Amongst the varieties of *H. sabdariffa*, RT-1 was found to be least affected by the pest.

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# EFFECT OF GRADING AND SOME PRETREATMENTS ON THE QUALITY OF DEEP FAT-FRIED BEANS (*DOLICHOS LABLAB*)

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In deep fat frying of field beans, if the raw material is not graded for maturity, it results in a product of undesirable quality, i.e. under fried and over fried bits because of the variations in the frying times required for pieces of different maturity. Beans when fried as such make excessive spurting which results in loss of the beans and fat, causes inconvenience to the operator and gives a product with partially broken and shrivelled up cuticle. To overcome these defects, effect of grading and some pretreatments like blanching, precooking and steeping in solutions of sodium chloride, potassium metabisulphite (K.M.S.) and citric acid were studied and the results are briefly described in this article.

## MATERIAL AND METHODS

For grading, a series of brines of concentrations varying from 2 to 16 per cent (wt./wt.) were prepared and 100 gm. batches of fresh field bean seeds were added to each. The floated beans were removed in each case, wiped with a cloth and weighed. On the basis of visual appearance, the beans were graded into tender, partially mature and mature seeds. Mature seeds were used for studying the effect of some pretreatments on the quality of the fried product. The results of pretreatment trials were (i) blanching in boiling water and solutions of sodium bicarbonate and sodium hexametaphosphate of different concentrations for varying periods to remove the cuticle, (ii) the seeds after the removal of cuticle were steeped for 15 minutes at room temperature in 1 per cent sodium chloride solution, 0.4 per cent KMS solution, and 0.5 per cent citric acid solution, (iii) steam cooking of seeds after the removal of cuticle at 5 p.s.i.g. for different periods. Except in treatment (iii) where no washing was necessary the material after each treatment was thoroughly washed in running water. Beans of different stages of maturity and mature beans after the pretreatments were separately fried in hydrogenated groundnut oil heated to 190°C. and taken out at a temperature of 175°C. The period of frying was five minutes in all cases except where otherwise stated. The oil to material ratio was 5:1.

The organoleptic evaluation of the fried products for colour, flavour and texture was made by a panel of judges selected from the staff of the Institute. Average of six separate scorings was taken as the standard for quality evaluation. The judges were asked to score according to the following scheme.

- (i) Excellent— Score of 80 and above.
- (ii) Good— Score of 70 to 79

- (iii) Acceptable— Score of 60 to 69
- (iv) Fairly acceptable— Score of 50 to 59
- (v) Unacceptable— Score below 50.

Colour was also measured by Lovibond Tintometer using reflected light. Proximate composition of beans was determined by A.O.A.C. (1955) methods for plant materials. Proteins soluble in five per cent salt solution were determined by Chamberlain's (1947) method.

## RESULTS AND DISCUSSION

*Grading:* Data on grading of field beans by brine floatation method (Table I) show that field beans can be effectively graded for maturity by the difference in the specific gravity at different maturity levels. In a typical batch of field beans, brine of six per cent concentration separated about 18 per cent of mainly tender beans and that of nine per cent concentration separated about 28 per cent of mostly partially mature beans. However, a small percentage of tender and partially mature beans remained after floating in nine per cent brine which could be picked out by manual labour.

TABLE I. GRADING OF FIELD BEANS BY BRINE FLOATATION METHOD

Brine concentration Per cent wt.	Specific gravity of brine 15°C/15°C	Per cent floatation	Visual grading of maturity		
			Green Tender per cent	Yellowish green Partially mature per cent	Greenish yellow mature per cent
2	1.0145	6.3	5.1	..	1.2
4	1.0230	14.0	12.0	..	2.0
6	1.0437	18.0	15.0	0.5	2.5
8	1.0585	32.0	16.4	12.6	3.0
9	1.0659	46.0	17.0	26.5	2.5
10	1.0734	69.0	18.3	28.4	22.3
12	1.0886	78.0	19.0	27.2	31.7
14	1.1038	84.0	17.8	28.8	37.4
16	1.1194	96.0	18.0	30.2	47.8

*Proximate composition of graded beans:* Composition of beans of different maturity given in Table II shows that it is not possible to correlate the maturity with any of the components studied.

*Effect of maturity on the organoleptic quality of the fried product:* Data regarding effect of maturity on the organoleptic quality of fried product (Table III) show that tender beans tended to absorb more fat, which imparted a slight oily flavour to the product. Partially mature beans were acceptable with respect to flavour and texture,

but the colour was not considered so attractive as of mature beans. Mature beans of light yellow colour were considered best from the point of view of colour and texture, though flavour was rated lower than that of partially mature beans.

TABLE II. PROXIMATE COMPOSITION OF FIELD BEANS OF DIFFERENT STAGES OF MATURITY

Constituents	Tender	Partially mature	Mature
Moisture	70.00	62.21	54.03
Ash	1.25	1.28	1.32
Total nitrogen	1.50	1.65	1.91
Non-protein nitrogen	0.39	0.20	0.18
Protein ( $N \times 6.25$ )	6.94	9.06	10.81
Ether extract	0.10	0.15	0.12
Crude fibre	3.10	3.51	4.20
Carbonhydrates by difference	18.61	23.79	29.52

TABLE III. EFFECT OF MATURITY ON THE ORGANOLEPTIC QUALITY OF THE FRIED PRODUCT

Maturity	Moisture	Fat	Visual colour	Lovibond colour units			Organoleptic score				Remarks
				Red	Yellow	Blue	Colour	Flavour	Texture	Average	
Tender	3.36	28.28	Pale green	1.1	9.9	3.0	55	70	70	58.3	Slight oily flavour
Partially mature	4.16	22.60	Yellowish green	0.6	8.0	1.5	60	80	70	70.0	Good
Mature	3.78	23.00	Light yellow	1.4	5.0	0.0	80	70	75	75.0	Good

*Blanching to remove the cuticle:* Removal of cuticle in beans before frying helps to reduce spurting losses, eliminates danger to the operator, reduces frying time and gives a uniform colour to the product.

Attempts were made to remove the cuticle of beans by steeping in boiling water and solutions of sodium bicarbonate and sodium hexametaphosphate of different concentrations for varying periods. The removal of cuticle was considered complete when the bean on gently pressing between the fingers freed itself from the cuticle. Boiling in water upto six minutes was not fruitful. Even after ten minutes, though the beans were cooked, they did not free themselves from the cuticle with ease. Blanching in 0.5 per cent sodium bicarbonate or sodium hexametaphosphate solution could bring about only partial removal of the cuticle and the beans became slightly cooked by that time. Higher concentrations of two and three per cent sodium bicarbonate or sodium hexametaphosphate were not satisfactory because of cooking

of beans after three to four minutes boiling, though the removal of cuticle was easy. Steeping in boiling one per cent sodium bicarbonate or sodium hexametaphosphate solution for four minutes was found to be the best procedure, since there was no considerable cooking effect.

*Loss of nutrients during blanching:* Having arrived at a suitable blanching procedure for the removal of cuticle, it was thought to find out the loss of important nutrients during this process. Data on this aspect (Table IV) show that expressed on dry weight basis the loss is about six per cent of proteins, 40 per cent of salt soluble proteins, 28 per cent of ether extract and 16 per cent of minerals. Losses of minerals and salt soluble proteins are fairly high and are probably comparable to losses, during blanching in canning and dehydration.

TABLE 4. LOSS OF NUTRIENTS DURING BLANCHING OF FIELD BEANS

Constituents per cent on dry weight basis	Fresh beans	Blanched beans	Per cent loss on dry weight basis
Moisture (fresh wt. basis)	58.40	61.80	..
Ash	2.24	1.89	15.53
Protein (N $\times$ 6.25)	17.25	16.19	6.15
Protein (N $\times$ 6.25) soluble in 5 per cent salt solution	15.75	9.25	41.27
Ether extract	0.36	0.26	27.77

*Saving in fat due to removal of cuticle:* In a typical experiment, determination of fat content in the separated seed coat after frying of field beans, showed a saving of 8.4 per cent fat in the fried product if the cuticle was removed before frying.

*Effect of blanching on the quality of fried product:* Having found the need for and the advantages of blanching, it was of interest to know the effects of blanching on the organoleptic quality of the fried product. The results obtained in case of beans fried with and without cuticle and before and after blanching (Table V) show that blanching improves the crispness of the fried product, but increases the fat absorption by about five per cent. Colour as measured by red units of Lovibond Tintometer, was slightly better in case of unblanched material fried with cuticle than in others, but its organoleptic quality was poor due to non-uniformity in the visual colour of the product. The material fried after blanching and cuticle removal, was superior to the rest having a better crispness and uniform colour.

*Effect of steeping in SO<sub>2</sub>, CaCl<sub>2</sub>, NaCl and Citric acid solutions on the quality of the fried product:* The results obtained (Table VI) show that calcium chloride has a tendency to darken the colour and increase the hardness of the product. In agreement with earlier findings (Kengchock *et al.*, 1957), there was considerable reduction in fat uptake in the calcium chloride treated batch, but it was organoleptically unacceptable due to its hardness. Treatment with sulphurdioxide, though showed a slight decrease in the red units was inferior to control with respect to flavour. The increased fat

TABLE V. EFFECT OF CUTICLE REMOVAL BY BLANCHING ON THE ORGANOLEPTIC QUALITY OF FRIED FIELD BEANS

Treatment before frying	Frying time (Mts.)	Moisture per cent	Fat per cent	Lovibond colour Units			Organoleptic score				Remarks
				Red	Yellow	Blue	Colour per cent	Flavour per cent	Texture per cent	Average per cent	
Unblanched with cuticle	7	4.0	17.7	1.4	4.0	0.0	70	60	68	66.0	Slightly bitter but acceptable
Unblanched, with cuticle removed by hand	6	3.9	17.9	1.9	4.0	0.0	85	82	70	79.0	Good
Blanched in 1 per cent boiling sodium bicarbonate solution for 4 mts., cuticle retained	6	3.5	23.1	1.8	4.0	0.2	75	74	70	73.0	Good
Cuticle removed after blanching in 1 per cent boiling sodium bicarbonate solution	5	3.5	22.6	1.5	4.0	0.2	80	78	80	79.3	Good (Crispness better than 1, 2, and 3)

Moisture, fat and colour determinations made on fried material after removing the cuticle.

TABLE VI. EFFECT OF STEEPING IN  $\text{SO}_2$ ,  $\text{CaCl}_2$ ,  $\text{NaCl}$ , AND CITRIC ACID SOLUTIONS ON THE QUALITY OF THE FRIED PRODUCT

Treatment given after cuticle removal by blanching (steeping time 15 minutes)	Moisture per cent	Fat per cent	Lovibond colour units			Organoleptic score				Remarks
			Red	Yellow	Blue	Colour per cent	Flavour per cent	Texture per cent	Average per cent	
Control steeped in ordinary water	3.56	26.7	2.2	6.0	0.3	72	74	80	75.3	Good
Steeped in 1.0 per cent sodium chloride solution	3.45	24.7	2.5	6.0	0.5	60	58	61	59.7	Harder and darker than control. Fairly acceptable
Steeping in 0.4 per cent. potassium metabisulphite.	3.38	25.9	2.0	6.0	0.2	72	68	74	71.3	Good Very hard
Steeping in 0.5 per cent. Calcium chloride solution	3.48	16.5	2.8	6.0	0.9	38	42	42	40.7	Colour darker than control. Unacceptable
Steeping in 0.5 per cent citric acid solution	3.60	24.5	2.3	6.0	0.4	60	64	56	60.0	Slightly harder and darker than control. Unacceptable

uptake resulting from sulphitation at temperatures ranging from 86 to 149°C, as observed by previous workers (Stutz and Burris, 1948) in case of potato chips, has not been noticed in case of beans. In general, none of the treatments tried was found to improve the quality of fried product.

*Effect of preliminary cooking on the quality of the fried product:* Data in Table VII show that the product darkens considerably by cooking as shown by increase in red and blue Lovibond colour units, and there is a tendency to absorb more fat as the product is cooked more and more. After three minutes cooking the product becomes completely unacceptable because of very dark colour and oily taste.

TABLE VII. EFFECT OF PRELIMINARY COOKING ON THE QUALITY OF THE FRIED PRODUCT

Cooking time at 5 p.s.i.g. (Minutes)	Moisture per cent	Fat per cent	Lovibond colour Units			Organoleptic score				Remarks
			Red	Yellow	Blue	Colour per cent	Flavour per cent	Texture per cent	Average per cent	
0.0	3.6	26.7	2.2	6.0	0.3	72	74	80	75.3	Good
0.5	3.4	28.4	2.5	4.0	0.7	60	60	70	63.3	Slight oily flavour. Acceptable. Colour darker than control
1.0	3.5	27.8	2.6	4.0	1.2	60	55	70	61.7	Oily flavour
2.0	3.8	29.8	2.5	4.0	0.9	55	50	72	59.0	-do- Fairly acceptable
3.0	3.3	36.4	2.6	4.0	1.8	50	50	70	56.7	-do- Fairly acceptable

### SUMMARY

Effect of grading and some pretreatments like blanching, pre-cooking and steeping in solutions of sodium chloride, potassium metabisulphite and citric acid on the quality of deep fat fried field beans has been studied. The results show that (a) field beans used for deep fat frying can be graded for maturity by floatation in six and nine per cent brines (wt./wt.) which separate tender, partially mature and mature beans; (b) it is not considered possible to correlate maturity of beans with the proximate composition; (c) fried product from partially mature beans is good, but mature beans give the best product; (d) blanching in one per cent sodium bicarbonate or sodium hexametaphosphate for four minutes is the best method of removing cuticle, which helps to reduce spurting losses, eliminates danger to the operator, reduces frying time and gives a uniform colour to the fried product; (e) loss of nutrients during blanching of field beans, though quite high (six per cent proteins, 40 per cent salt soluble proteins, 28 per cent ether extract and 16 per cent minerals) is considered of the same order as in canning and dehydration; (f) removal of cuticle reduces fat

loss by about eight per cent in the field beans; (g) treatment with sodium chloride, calcium chloride, citric acid or sulphurdioxide has not been found to improve the quality of the fried product; (h) cooking of beans before frying increases the fat uptake and results in a fried product of inferior quality.

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# A PRELIMINARY NOTE ON THE CONTROL OF THE *BHINDI* SHOOT AND FRUIT BORER, *EARIAS FABIA* AND *E. INSULANA*

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During recent years, the spotted bollworms of cotton, *Earias fabia* Stall and *E. insulana* Boisd have assumed the role of serious pests of *bhindi* (*Abelmoschus esculentus* L.) in parts of the Madras State, causing on an average about 40-50 per cent damage.

Walker and Haidari (1952) have reported the usefulness of Endrin sprays in the control of this borer and its superiority over Dieldrin and Toxaphene, and their views were confirmed by Patel *et al.* (1954). Investigations on the control of the above pest are in progress at Coimbatore under the auspices of a scheme financed by the Indian Council of Agricultural Research. The object of this note is to record the results achieved during the summer season trials of 1957.

## MATERIAL AND METHODS

Seeds of the type Indian *bhindi* were sown on the 26th February, 1957 in 32 plots. There were seven insecticidal treatments and one control which were replicated four times in simple randomised blocks. In each plot, there were 96 plants, of which one guard row of 40 plants around was discarded. The insecticidal treatments were applied four times at intervals of about 10 to 15 days as given in Table I. The first application of the insecticides was given one week after the germination. The treatments were so adjusted as to give the maximum number of three rounds prior to the bulk fruiting stage of the crop with a view to avoiding toxic residues on the produce. In all, 15 harvests of the fruits were taken and the picking was done at intervals of three days approximately.

The ripe fruits were picked before giving the insecticidal treatments.

The results were assessed with reference to the percentage of affected shoots and the bored fruits in the different plots. For the former, three rounds of estimations at monthly intervals were made. Regarding the latter, the produce obtained at each harvest was critically examined and the percentage of affected fruits was worked out under each treatment. The data gathered are given in Table I.

## RESULTS AND CONCLUSION

Sprays of Endrin 0.02 per cent and Dieldrin 0.1 per cent have given the best results as discussed below. Aldrin 0.1 per cent and Toxaphene 0.1 per cent were on a par and were the next best to Endrin 0.02 per cent and Dieldrin 0.1 per cent; Endrin 0.02 per cent has given the highest yield of good fruits both by number and weight. Dieldrin 0.1 per cent, Aldrin 0.1 per cent and Toxaphene 0.1 per cent were on a par in this respect and came next in order of merit. Dieldrin 0.1 per cent, Endrin 0.02 per cent, Aldrin 0.1 per cent and Toxaphene 0.1 per cent have controlled the

incidence of this pest on shoots and are better than D.D.T. 0.1 per cent, Parathion 0.025 per cent and Pestox 0.1 per cent.

TABLE I. CONTROL OF THE BHINDI AND FRUIT BORERS—*EARIAS FABIA*, AND *E. INSULANA* IN MADRAS STATE

Plot size: Gross: 32 ft. × 9 ft. Net: 28 ft. × 6 ft.		Date of sowing: 26-2-1957 Dates of spraying: 12-3-1957, 23-3-57, 9-4-57 and 31-4-57 Period of harvest: 9-4-57 to 15-5-57				
Treatments	Mean percentage of borer incidence on fruits (weight basis) (i)	Mean percentage of borer incidence on fruits (number basis) (ii)	Mean percentage of shoot borer incidence (iii)	Mean yield of borer free fruits in an experimental plot (weight) (iv)	Mean yield of borer free fruits in an experimental plot (number) (v)	Net income in an acre on account of the treatment Rs. nP.
1. Endrin 0.02 per cent	3.3	3.5	2.4	Lb. Oz. 15.8	614	341.25
2. Dieldrin 0.1 per cent	5.8	5.3	0.18	9.13	449	53.30
3. Aldrin 0.1 per cent	11.5	11.0	2.4	7.15	371	97.50
4. Toxaphene 0.1 per cent	14.9	13.6	5.5	9.9	390	162.50
5. D.D.T. 0.1 per cent	27.3	27.0	17.0	6.6	285	125.45
6. Parathion 0.025 per cent	29.9	30.4	23.9	5.7	257	40.95
7. Pestox 0.1 per cent	48.0	48.6	27.7	4.8	181	65.00
8. Control	48.8	46.4	29.7	2.2	109	69.12
Critical Difference	3.6°	3.4°	7°	3.03°	72	

Bar Diagram:— (i) 1, 2, 3, 4, (ii) 1, 2, 3, 4, (iii) 2, 1, 3, 4, (iv) 1, 2, 4, 3, (v) 1, 2, 4, 3,  
5, 6, 7, 8 5, 6, 8, 7 5, 6, 7, 8 3, 5, 6, 7, 8 5, 6, 7, 8

Endrin 0.02 per cent spray applied four times at intervals of about 10 to 15 days, commencing about the second week stage of the crop has given the best results in the control of *Earias fabia* and *E. insulana* on *bhindi*. The above experiment was primarily designed to evaluate the efficacy of some of the modern insecticides in controlling these serious pests of *bhindi* and also the number of rounds required for satisfactory control. Endrin 0.02 per cent has been found as the most promising and useful insecticide. But Endrin is usually sprayed in the form of an emulsion which might penetrate the fruits left unpicked, and so it is proposed to conduct further trials by stopping the treatments prior to fruit formation and assess the degree of control that can be obtained. Therefore, in conclusion, the following will have to be stated. Since the

persistence of Endrin residue has not been studied in India, it is difficult to say anything regarding its safety when applied after fruit formation. Hence, particular care has to be taken to see that the maximum number of three or four rounds of treatments are given before fruit formation and stopped with a view to avoiding residues on the produce. Endrin was observed to control the other serious pests of *bhindi* viz., jassids and aphids. It was also observed to stimulate the growth of *bhindi* plants considerably and induce greater production of flowers even with two rounds of applications. So spraying of Endrin 0.02 per cent three to four times commencing from the first week stage of the crop and stopping just prior to fruit formation seems to be worthy of adoption for controlling the *bhindi* bores. However, the same should be used judiciously and with caution.

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# OBSERVATIONS ON THE CROP EXPRESSION OF ARBOREUM COTTON IN THE VICINITY OF *PROSOPIS* HEDGE

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Among the recent plant introductions with which farmers in Madras have become familiar, the most widely known is *Prosopis juliflora*. As a hedge plant to protect field crops against cattle browse and human trespass, it has become an ideal live fence. Its established growth, of a few years standing, however, appears to have some adverse influence on the agronomic expression of field crops in its vicinity. This is the general experience of most of the farmers in this State. Such a phenomenon was observed on a crop of Karunganni cotton (*Gossypium arboreum* race *indicum*) in a field of the Cotton Breeding Station, Coimbatore, during 1957-58. In this paper data on characters which were affected to varying degrees in that portion of the field close to the live fence as compared to that away from the fence are presented.

Ponnayya *et al.* (1951) have discussed the multifarious uses of mesquite but did not study its deleterious influence on adjoining cultivated annuals. Weaver (1924) and Jean (1926) carried out extensive investigations on the morphology and activities of the root systems of various cultivated farm crops in relation to crop productivity, but very little work on these lines has been done in this country.

## MATERIAL AND METHODS

Karunganni-5, (K. 5) an unirrigated *desi* strain evolved at the Cotton Breeding Station, Coimbatore, now under extensive cultivation in this district and sown in field 10-E of the Cotton Breeding Station, Coimbatore, as a bulk crop, provided the required material for the study. This field was bound on the east by a fence of *Prosopis* 500 feet long, about 12 feet high and not less than five years of establishment. The crop had been raised in drill lines two feet apart almost parallel with the hedge line. Sowing was done in the last week of September, 1957 and harvest was completed in April 1958. There was nothing note-worthy in the crop over the entire field in regard to germination, stand and growth up to four weeks after sowing. After this date, the plants close to and up to varying distances from the hedge lagged in growth and were relatively more stunted and less branched than the bulk of the crop away from this zone of curb.

A rough survey of the spread of the zone of curb was obtained by first walking along and close to the hedge line, cutting across the field at right angles from random stops on this hedge line and then selecting points on corresponding perpendicular lines on these stops such that the points indicated approximately transitions from stunted to normal growth. As the crop had been sown in lines parallel to the hedge,

no difficulty was experienced in this survey. About a dozen points thus selected along a distance of 250 feet of *prosopis* hedge were connected to give a wavy line separating the zone of curb (shaded portion in Fig. 1) from that of the normal growth. Four successive corridors 20 feet deep each (A, B, C, and D in Fig. 1) parallel to the hedge line and away from it were partitioned such that 'A' was well within the zone of

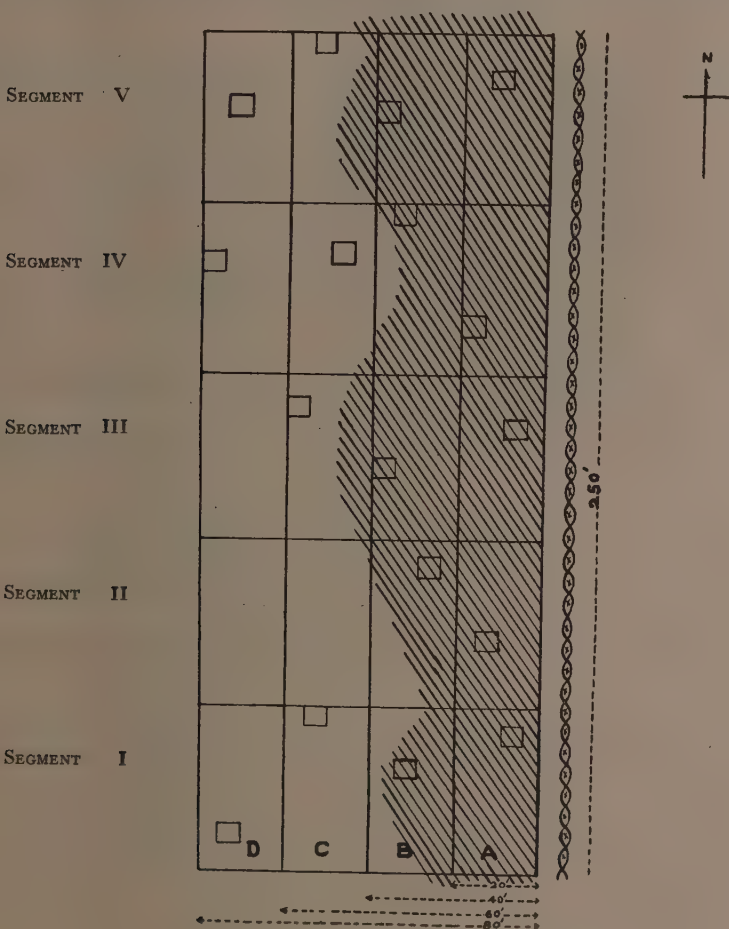


FIG. 1. CROP EXPRESSION OF ARBOREUM COTTON IN THE VICINITY OF *PROSOPIS* HEDGE

LEGEND:

1. *Prosopis* Hedge Line
2. ABCD: Successive corridors 20' in width away from hedge
3. Shaded area is the zone of growth-curb
4. Segment I etc. denote replications
5. Squares in a replication represent spots of 100 square feet each—locations randomised

curb, 'D' out of it and 'B' and 'C' in between. The corridors were then cut up into five segments. In each segment 'spots' measuring 100 square feet each were marked. Four spots distributed at one for each corridor length were chosen at random in each segment. The segments were taken as equivalent to replications and the corridor widths as variants. The entire layout is furnished in Fig. 1.

*Stand*: Number of plants at commencement of harvest, i.e., in the last week of March was recorded.

*Height Measurement*: Plant height was measured in centimeters from seed leaf node to terminal bud. 'Top bored' and diseased plants were avoided. Mean plant height per spot was obtained by averaging the readings thus recorded.

*Productivity*: The total number of bolls was counted for each plant at commencement of bursting. This count included mature bolls and other bolls likely to contribute to the season's harvest. Mean number of bolls for the plants thus counted was taken to denote 'spots' productivity.

*Earliness*: Number of burst bolls in each 'spot' area on the first day of harvest was expressed as a percentage of the total number of bolls for the season and the mean of those percentages denoted earliness.

*Yield*: The entire harvest from the spot gathered periodically and accumulated in a container was weighed to record yield in ounces of *kapas*. Yield in pounds of *kapas* per acre was calculated from these data.

*Halo length*: Halo-length measurements in millimeters were taken on composite samples of 25 seeds chosen at random from the entire spot harvest and means worked out.

*Seed and lint indices*: Two hundred seeds were chosen at random from the *kapas* samples of the entire season and weights of 100 seeds and the lint on 100 seeds were calculated to obtain seed index and lint index respectively from data on weighments made before and after ginning the *kapas* with a table model Gin.

*Seed viability*: One hundred seeds from each spot sample were raised in germination trays a month after final harvest, and the percentages of germination on the seventh day after starting was recorded.

*Fibre properties*: Composite lint samples representative of the entire season harvest were tested for mean fibre length inch (Balls' sorter), mean fibre length in millionth of a gram per centimeter, percentages of mature, half mature and immature fibres and bundle strength with the Pressley Strength Tester.

The results were statistically analysed for items one to eight on Fisher's randomized technique basis. The results on fibre properties had to be done on composite samples as the sample from each spot was not sufficient for individual tests.

## RESULTS

The results are summarised in Table I. It will be observed that there is a progressive deterioration in expression for the following characters as the crop approaches the hedge line: height, productivity, yield, seed-index, viability of seed, and bundle strength. The reduction is most pronounced in the 20 feet corridor compared to the 80 feet corridor representing normal development. Karunganni-5 within a zone of 20 feet from *Prosopis* suffered a reduction in its yield potential by about 57 per cent.

TABLE I. EFFECT OF PROSOPIS ON CROP EXPRESSION IN KARUNGANNI 5

Variant	Mean Stand	Mean height in cm.	Productivity (mean number of bolls)	Barliness (mean %)	Mean calculated yield in pounds of kapas per acre	Mean halo length in cm.	Mean seed Index	Mean line Index	Mean Ginning % (composite sample)	Viability (mean %)	Mean fibre length in inch	Mean fibre weight in millionth of a gram per centimeter	Mature	Half Mature	Immature	Pressly strength Index lb./m.g.m.
80 feet from hedge line (Control)	269	45.6	260.6	17.0	359	22.2	64.8	26.6	29.8	92.8	0.85	2.08	81	8	11	7.85
60 -do-	231	44.2	235.2	<b>23.2</b>	305	22.0	62.0	27.6	<b>30.8</b>	91.2	0.84	2.16	78	10	12	8.13
40 -do-	241	41.8	174.2@	<b>28.4</b>	257@	21.5	60.2@	27.0	<b>30.8</b>	90.4	0.85	2.14	85	6	9	7.80
20 -do-	279	34.8@	124.6@	<b>54.2</b>	165@	21.6	55.8@	25.6	<b>31.2</b>	85.6@	0.86	2.12	84	7	9	7.42
Significance for P=0.05	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	..	..	..	..	..	..
S.E.M.	..	1.55	16.7	1.9	1.1	..	1.18	..	0.28	1.56	..	..	..	..	..	..
Critical difference	..	4.8	51.4	5.9	93	..	3.7	..	0.9	4.8	..	..	..	..	..	..

@ denotes values lower than control.  
Bold figures denote value higher than control.

Stand of the crop was not affected, which indicates the capacity of the strain to withstand severe competition. Neither were major characters of quality like halo-length, fibre-length, fineness (fibre weight) and maturity of fibres affected. The quality of lint produced on the seed was also not affected. But there was an increase in the ginning percentage in the 20 feet zone. This was due to reduced seed weight.

## DISCUSSION

The field in which the crop had been sown was in level with the hedge line. It had no slope, gullies, depressions with scope for washes or inundation during rains or other unusual topographical features likely to interfere with normal crop growth. Parts of the other sides of the field had hedges of *Ipomoea* periodically cut for green manure needs. The southern side was bound by a row of trees. Portions of the crop lying near the hedges were also stunted to varying distances. The investigations reported here were restricted to the portion near *Prosopis* hedge as reduction in crop expression was more spectacular here than elsewhere.

The characters in which the setback was most pronounced were plant height, yield and productivity. Bolls of plants in the proximal region ripened much earlier than those in the distal zones indicating forced earliness under a new environment. Boll opening was premature.

It will be observed from these results that wherever Karunganni is cultivated, the portion of the crop coming within the zone of curb not only suffers a reduction in yield but in quality as well because of weakened fibre. Proportion of such weak lint in the crop harvested from the field depends upon the area of the zone of curb and since no farmer can be expected to take such pains as to keep the produce from this area distinct from the rest, there is always the risk for the entire harvest being discounted by the trade as off the standard quality even though the whole field is raised with the best pedigree seed.

These observations would suggest the need for more thorough long-range investigations on the following lines.

1. Marking spots in the zone of curb and digging trenches around some spots. Random population in the centre of the spot thus trenched around with a similar population from spots not so trenched to be studied for characters of agronomic and breeding importance.
2. Study of plants in contemporaneous segments, some separated by long continuous trenches of known length from the *Prosopis* hedge line and some without the trench.
3. Raising *Prosopis* hedge in an interrupted manner at regular intervals with a view to comparing crop expressions in the region close to the hedge line and on corresponding regions close to the blank lines.

In all these studies data on stage of staggering in growth from sowing date by periodical measurements of height, extent of root-systems, loss in plant matter by weight of stalks after harvests, depth and width of trenches and complete data on yield and quality characters of the concerned cotton crop need to be gathered.

In the absence of results from these investigations and until such time as these become known it is a safe policy for agricultural experimenters to exclude a distance of about 40 feet from the hedge of *Prosopis* of a few years standing and about 12 feet high for experimental purposes.

#### SUMMARY

K. 5, an *arboreum* cotton evolved at the Cotton Breeding Station, Coimbatore, under extensive cultivation in Coimbatore in the vicinity of a well established hedge of *Prosopis* suffers in crop expression. The effects are noticed in the shape of stunted growth (24 per cent off normal), reduced yield (57 per cent off normal), and weakened fibre (6 per cent off normal) and this influence extends upto a distance of 40 feet from the hedge. It would seem necessary to exclude a distance of about 40 feet from the hedge for serious experimental studies, varietal or agronomical. The operational causes are not known. Lines of investigations are indicated.

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# STUDIES ON TILLAGE

## VIII. EFFECT OF VARIATION IN DEPTH OF CULTIVATION IN CONJUNCTION WITH FERTILIZERS AND THEIR MODE OF APPLICATION ON THE YIELD OF CARROT (*DAUCUS CAROTA*)

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In the mixed economy of Indian farmer the place of root crops is vital. It seems that carrots can be successfully grown for livestock feed and their nutritive value compares favourably with the conventional fodder crops. The yield of fresh carrots is better than corn or alfalfa hay. They are rich in carotene, a precursor of vitamin A, and are liked for their succulence and palatability.

The cultivation of roots has revolutionized British agriculture by replacing fallow with inter-tilled row crops. This system is in a way better than fallow from the standpoint of keeping the land clean and productive.

For crop production in general and root crops in particular there is perhaps no single factor which could excel thorough tillage in pushing up the yield. Though this may be so, yet knowledge regarding suitable type of implements and the depth to which they should be worked is still meagre. This needs to be enquired into.

The other factors which help in increasing the production of roots are the balanced nutrients and their effective manner of application.

Keeping these facts in mind a project with carrot was started in the year 1952 on the farm attached to the Indian Agricultural Research Institute, New Delhi. This paper presents the data obtained during the period of five years.

### MATERIAL AND METHODS

The experiment was conducted on an irrigated piece of land in a split plot design with four replications. The details of treatments follow:

#### (a) *Cultivation*

- C<sub>1</sub> Ploughing 9"-10" deep with tractor (inversion) plough followed by normal cultivation with tractor implements.
- C<sub>2</sub> Ploughing to a depth of five inches with bullock-drawn (inversion) plough followed by normal cultivation with local wooden plough.
- C<sub>3</sub> Ploughing with local wooden plough to a depth of five inches, without inversion.

#### (b) *Application of fertiliser*

- 1. Placed (plough sole)
- 2. Broadcast

(c) *Fertiliser ratios*

N<sub>1</sub>—NPK, in the ratio of 80:80:40 lb. per acre.

N<sub>2</sub>—NPK, in the ratio of 120:80:40 lb. per acre.

N<sub>3</sub>—Nitrogen alone at 120 lb. per acre.

The 18 treatment combinations were divided into six main plots for ploughing and application of fertiliser. They were further split up into three sub-plots for fertiliser ratios.

*Soil*: The land used for the purpose was a sandy loam. The soil was of average fertility and of good drainage. The separates consisted approximately of 76 per cent sand, 10 per cent silt and 13 per cent clay. The pH of the plot was 7.9.

The soil studies have shown that the percentage of water stable aggregates (1.19 mm. to 4.76 mm.) was higher in treatment C<sub>1</sub> followed by treatment C<sub>2</sub> and C<sub>3</sub> respectively.

The data for moisture equivalent as affected by the different cultivation treatments were analysed statistically but the differences were not found to be significant.

The permeability measurement has shown that it was not significantly affected by the different cultivation treatments.

The percentage of moisture in the top layer of soil as obtained under the different cultivation treatments, at sowing of carrots was 14.15, 13.87 and 13.82 for C<sub>1</sub>, C<sub>2</sub> and C<sub>3</sub> treatments respectively.

## RESULTS

In order to examine the trend of treatments for a number of years the data relating to different years were pooled and analysed. The results obtained are summarised in Tables I, II and III.

TABLE I. YIELD OF INDIVIDUAL YEARS AS WELL AS AVERAGE YIELD OF ROOTS FOR 1952-1956 (MD. PER ACRE)

Treatments	1952-53	1953-54	1954-55	1955-56	1956-57	Overall average for depth of cultivation
C <sub>1</sub>	591.67	250.23	270.28	282.32	474.73	373.85
C <sub>2</sub>	559.05	204.80	297.07	287.36	498.84	369.42
C <sub>3</sub>	606.55	210.31	269.50	270.22	482.43	367.80
Yearly averages	585.76	221.78	278.27	279.97	485.33	..
'F' test	Not sig.	Sig.	Not sig.	Not sig.	Not sig.	Not sig.
S.E.m. $\pm$	29.95	8.65	11.92	5.47	21.07	9.13
C.D. 5 per cent	..	26.07	..	..	..	..
		S.E.m. for years	$\pm$	23.97		
		C.D. 5 per cent		66.76		

The soil fabric prepared by alternative form of tillage implements did not show much difference in the quality of tilth. The differences in the yield of carrot were, therefore, negligible.

The differences between years were found to be significant and reflect generally the effect of the season without abnormally affecting any particular treatment in a season.

TABLE II. EFFECT OF FERTILIZER-RATIOS ON THE YIELD OF CARROTS IN MD. PER ACRE

Treatments	Years					Overall average (5 years)
	1952-53	1953-54	1954-55	1955-56	1956-57	
N <sub>1</sub>	585.07	237.52	273.49	285.34	502.72	376.83
N <sub>2</sub>	617.42	217.84	296.74	270.22	472.49	374.49
N <sub>3</sub>	554.62	210.00	256.45	283.33	482.43	357.57
'F' test	Not sig.	Sig.	Sig.	Not sig.	Not sig.	Sig.
S.E.m. $\pm$	26.30	5.36	14.43	4.36	10.01	7.92
C.D. 5 per cent.	..	15.36	28.20	..	..	22.73

The differences in yield for the period as a whole are significant. It is evident from the above table that a mixed dose of major nutrients (NPK) is better than a single dose of nitrogen. This indicates the importance of balanced nutrition for the carrot crop. It is also seen from the above table that a higher dose of nitrogen is not conducive to bigger yield. The difference between N<sub>1</sub> and N<sub>2</sub> is not statistically significant and both are superior to N<sub>3</sub>.

TABLE III. EFFECT OF PLACEMENT OF FERTILISERS ON THE YIELD OF CARROT (IN MD. PER ACRE)

Treatments	Years					Overall average (5 years)
	1952-53	1953-54	1954-55	1955-56	1956-57	
P	554.38	180.29	268.32	283.33	489.99	355.26
T	617.14	263.28	282.81	276.27	481.77	384.25
'F' test	Sig.	Sig.	Not sig.	Not sig.	Not sig.	Sig.
S.E.m. $\pm$	21.40	7.06	9.72	4.47	17.39	7.46
C.D. 5 per cent	61.15	21.28	..	..	..	22.47

The average response has been observed to be significant in favour of top-dressed application. The placed method of fertilizer application does not appear to suit this crop under the condition of this experiment.

None of the interactions was found to be significant; hence, the data relating to them have not been presented.

### DISCUSSION

The soils under the experiment have been well-drained and well-managed. Due to smothering effect of green manure crop which preceded carrot there was no weed growth. Russell (1945) and Keen (1949) attribute the effect of deep ploughing to a comparatively cleaner seedbed which was not the problem in this case. Browning *et al.* (1950) observed little difference in plant growth and yield, irrespective of tillage treatments, on soils having a good physical condition. Similar observations were made by Wright (1914), Weaver and Bruner (1927), Torstenson (1943), Porge *et al.* (1946), Doneen (1947), Patton *et al.* (1943), Constable and Pollard (1952) and Khan (1953) besides many others. A negligible difference in yield due to tillage treatments may perhaps be due to reasons explained above.

Among the fertilizer ratios, treatment  $N_1$  has given the highest yield and was closely followed by  $N_2$ . Both of them were significantly superior to  $N_3$ . Lyon *et al.* (1952) have emphasised the need of balancing nutrients in suitable proportion for the use of plants. They think the presence of too large an amount of one element may be as detrimental as an actual lack of the same constituent.

Wallace (1941), Moore (1948) and Cowie (1951) stated that requirements of carrot for nitrogen were low and only a moderate application should be enough. Similarly Boshart (1938), Thompson (1949) and others stressed the need of potash for obtaining bigger returns of carrot. Newsod *et al.* (1940), Woodman (1940), Helper (1945) have recommended the application of complete fertilizer for obtaining good yields. Woodman has reported that deficiency of any one of them has resulted in decreased yield of carrot.

As has, from the above evidence been established the nitrogen requirement of carrot is low and so the yield obtained from treatment  $N_3$  was the lowest. It appears from the results that the nutrients were well-balanced in treatment  $N_1$ .

In regard to mode of application of fertilizers the yield was significantly higher in case of 'broadcast' application than the placed method. Weaver (1927) observed that carrots have a characteristic root system forming an extensive absorbing zone near the surface. This might have helped in better absorption of fertilizer applied as broadcast.

Baur and Trembley (1943), Hewitt (1944), Crowther (1950) and Cook and Widdowson (1953) from their experiments on carrot, mangold and beet obtained higher yields by broadcasting the fertilizer mixtures than by placing them below the seed or in the furrow.

From his earlier studies at Rothamsted, Cook (1939) concluded that placement was of particular value for crops with limited root range or for crops which were sensitive to nutrient deficiency. This was not so here.

The interactions between various treatments were not found to be significant, hence they have not been discussed.

## SUMMARY AND CONCLUSION

It may be said that carrot crop does not respond to deep cultivation. It was also observed that on weed-free land, the effect of inversion is not marked. No significant difference in yield was observed between the seedbed produced by the local wooden plough and other tillage implements.

It has been established from this study that the nitrogen requirements of carrot crop are low and that it responds to complete minerals. The optimum dose was found to be in treatment  $N_1$  (80 lb. N, 80 lb.  $P_2O_5$  and 40 lb.  $K_2O$ ).

The placed method of fertilizer application does not seem to be suitable for a root crop like carrot. Due to peculiar nature of its root system the surface application of fertilizers appears to be good.

## ACKNOWLEDGEMENTS

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## REVIEWS

**Plant Protection Bulletin 6** (7), March 1958. Published by the F.A.O.

The bulletin is a publication of the world reporting service on plant diseases and pests issued every month by the Food and Agriculture Organisation of the United Nations. Started in October 1952, the bulletin has carried articles on pests and diseases and their control in various parts of the world. Three of its constant features have been the information about outbreaks and new records of pests and diseases, plant quarantine announcements and news and notes pertaining to international meetings and efforts for plant protection. The bulletins have provided a valuable means of knowing about plant protection problems and activities in different parts of the world.

The bulletin for March 1958 contains two articles, one on the distribution and prevalence of potato virus diseases in Denmark and the other describes the construction and use of a home-made bellows duster for small farmers. In view of the fact that India grows sufficient potato to meet its own requirements, even though imports on small scale continue, any information on the diseases of the potato crop in other countries should be of considerable interest in this country. As a new record, a disease of citrus, suspected to be of virus origin in Bombay State, is mentioned. Another interesting information is about grain-eating Weaver birds of the genus *Quelea*, which are reported to be one of the most serious pests in tropical Africa, the control of which has been effected mainly by blasting in their dry season roosts. Some basic research on the biology of the birds has been planned on an international basis in tropical Africa. As a parallel, attempts to control flying foxes in India, which damage various growing fruits in Himachal Pradesh, Punjab and other areas, by blasting operations against the roosting mammals, may be mentioned. [K. B. L.]

**Plant Protection Bulletin 6** (7), April 1958. Published by the F.A.O.

The bulletin contains an article on the control of Angular leaf spot of bean in Columbia and another on the insect pests in British Colonial Dependencies in 1957. In the latter article, the control of cut-worms, *Agrotis* spp. in Hong Kong by spraying with endrin or D.D.T. has been shown to be more effective than by the application of poison baits. This is of interest in India also, where cut-worms constitute a serious pest of potato, gram and other crops. A new pest of common bean in Mysore *Smythurodes betae* has been recorded. (K. B. L.)

**Nuclear Radiation in Food and Agriculture** by DR. W. RALPH SINGLETON, D. Van Nostrand Co. Inc. 1958 Xii+379 pp. Price 64\$

The material of the book is based on some papers presented before the first International Conference on peaceful uses of atomic energy held in Geneva in 1955. The eight parts of the book deal with uses of radio isotopes in agriculture, studies on

photosynthesis, plant physiology, pathology and cytology, soils and fertilizers, genetic and biological hazards of nuclear radiation, genetic eradication of insect pests, crop improvement and food sterilisation. A careful selection of topics and of papers has made the book a very useful publication. The major lines of investigation using radio isotopes have all been touched and the lucid account given makes it a very interesting reading. A scientist interested in this field certainly gets a very clear impression about the ideas upon which recent developments are based. The book is recommended as worth having for scientists and libraries.

**Soil Management in India** by H. R. ARAKERI, G. V. CHALAM, P. SATYANARAYANA and ROY L. DONAHUE, Asia Publishing House, Bombay, 1959 (pp. 584+xix)—Rs. 25.00.

This book represents the first in the efforts of Indo-American cooperation to produce a series of test books on agriculture for use in India. The book has been written to serve as a text book for the degree course in agriculture in Indian Colleges. The writing up of this book was sponsored by the Indian Council of Agricultural Research and the Fertilizer Association of India. The authors are well known experts in agricultural sciences in their own fields and have put in admirable efforts to make the book as illustrative and up-to-date in information in the various aspects of soil management in India, as possible. The necessity of such a publication has been long felt. The book has been written in lucid manner.

The book is divided into 24 chapters. First thirteen chapters deal with different aspects of soil management while the remaining chapters deal with the management of soils for various crops. The introduction of the two general chapters "Climate" and "Fertilizers and their characteristics" will provide the basic information to both Indian and foreign readers. Further, the three appendices giving (A) vernacular names of common Indian crops, (B) the definition of terms and (C) the conversion factors will also prove very useful.

A few points suggest themselves after reading the book. In the first chapter, where the Soil Map of India has been included, it would have been instructive and useful to narrate briefly the chief characteristics of the main soil classes giving their local names in different States wherever possible. Similarly, in the second chapter which deals with the use of soil and tissue tests, the locations of 24 soil testing laboratories given on page 25 mentioning that "Location of two more laboratories have not been decided" might have been omitted, since by this time (1959) the locations of the other two laboratories have been decided. Moreover such topics should find no place in a text book. It would have been worthwhile to include topics like soil survey and planning for best land use and also soil reclamation. The definitions of "Fertilizer" (page 535) and "Manures" (page 539) require scrutiny in the light of the use of such terms in India.

The publication which is an excellent text book on the subject of Soil Management in India is recommended to all professors and students of agricultural colleges and also to progressive farmers and extension and research workers in agricultural sciences in this country. (S. P. R.)

## Instructions to Authors

Articles of agricultural interest are accepted for publication in the *Indian Journal of Agricultural Science*. The manuscript should be neatly typed (double space), and sent in duplicate to the Editor (Research), Indian Council of Agricultural Research, Krishi Bhavan, New Delhi. The articles should not exceed 20 typed pages. Preference will be given to papers containing results of original research. Normally, only one paper by the same author will appear in a single number.

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